Vol. XVIII. No. 2 Whole No. 148

FEBRUARY, 1918

MAR 16 1918

# SCHOOL SCIENCE AND MATHEMATICS

A Journal for All Science and Mathematics Teachers

*Founded by C. E. Linebarger*

SMITH & TURTON, Publishers

Publication Office, Mount Morris, Illinois

CHICAGO OFFICE, 2059 East 72nd Place, CHICAGO, ILL.

CHARLES H. SMITH
EDITOR
Hyde Park High School, Chicago

CHARLES M. TURTON
BUSINESS MANAGER
Bowen High School, Chicago

DEPARTMENTAL EDITORS

Agriculture—Aretas W. Nolan
*The University of Illinois, Urbana, Ill.*

Astronomy—George W. Myers
*The University of Chicago*

Biology, Research in—Homer C. Sampson
*The Ohio State University, Columbus*

Botany—William L. Eikenberry
*The University of Kansas, Lawrence*

Chemistry—Frank B. Wade
*Shortridge High School, Indianapolis, Ind.*

Chemistry, Research in—B. S. Hopkins
*The University of Illinois, Urbana, Ill.*

Earth Science—William M. Gregory
*Normal Training School, Cleveland, Ohio*

General Science—Fredric D. Barber
*State Normal University, Normal, Ill.*

Mathematics—Herbert E. Cobb
*Lewis Institute, Chicago*

Mathematics Problems—Jasper O. Hassler
*Crane Technical High School, Chicago*

Physics—Willis E. Tower
*Englewood High School, Chicago*

Physics, Research in—Homer L. Dodge
*State University of Iowa, Representing American Physical Society*

Science Questions—Franklin T. Jones
*University School, Cleveland, Ohio*

Zoology—Worrallo Whitney
*Hyde Park High School, Chicago*

Published Monthly October to June, Inclusive, at Mount Morris, Illinois
Price, $2.50 Per Year; 30 Cents Per Copy

Entered as second-class matter March 1, 1918, at the Post Office at Mount Morris, Illinois, under the Act of March 3, 1879.

"McIntosh Lanterns Are Honest Lanterns."

# Vitalize

your lectures, by showing pictures of the processes you are discussing.

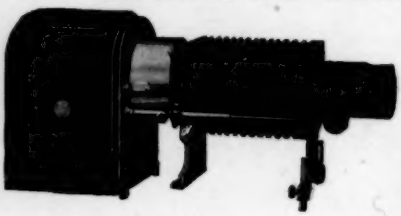
In Chemistry, you can show industrial processes which are based on applied Chemistry: Soap, Rubber, Asphalt, Paint, etc.

In Botany and Zoology; Life Cycles, Ecology, Dissections, Natural History.

In Geology; Weathering, Work of Water, Rivers and Valleys, Snow and Ice, Ocean, Vulcanizm, Sedimentation, etc.

In Physics; Mechanics, Heat, Sound, Light, Magnetism and Electricity.

**Lantern slides to illustrate all the above and much more are listed in our catalog S.**



And to project these slides there is no lantern like the Automatic Sciopticon, priced, complete with 400 Watt Gas-filled Mazda lamp, at **$38.00.**

Write for circulars and catalogs and submit your projection problems.

**McINTOSH STEREOPTICON COMPANY**
**410 Atlas Block, CHICAGO, ILL.**

*We Recommend*

# DETROIT

## Automatic Gravity Scales

***For Laboratory Use***

**No. 40—500 GRAM AUTOMATIC SCALE**

Does the work of six ordinary balances. Two models: 500 or 1500 gram capacity. For further information write

## Detroit Automatic Scale Co.
**Detroit, Michigan**

# SCHOOL SCIENCE AND MATHEMATICS

VOL. XVIII, No. 2 FEBRUARY, 1918 WHOLE No. 148

## THE SCIENCE ELEMENT IN EDUCATION.[1]

By L. H. BAILEY,
*Ithaca, N. Y.*

The address was divided into two general parts: First, an expression of opinion and point of view on the traditional division of educational topics into the arts and the sciences; second, the contribution of science teaching to the development of civic ideas, particularly to the achievement of democracy. On the old controversy between the humanities and the sciences, now again revived, he spoke as follows:

We are born to "things" and to "phenomena." We know things, smell them, wear them, handle them, see them. They comprise the goods of life. The phenomena represent the interplay of forces.

We cannot conceive of existence without things and phenomena. Even our conceptions of the state of immortality are imaginations of glorified material things, even to cities not made with hands. The life of the day is the life of experience with things. There is wood and objects made of wood; rocks and works in rock; land; trees, birds, quadrupeds, streams, hills; slants and levels and inclines; houses big and little; people; the sky; the light and the dark and the gloaming; machinery; food; fabrics wonderfully fashioned of many wonderful materials; ships and the sea under them; timeless shores; great cities and the vast accumulations in them; things that are and things that have been; action and reaction of materials and of forces; actions present and actions past; movement everywhere, quiescence everywhere; numbers and the relations of numbers; quantities; the human mind. The regulated knowledge of things and phenomena is science.

As we depend on things and phenomena, so is the science of them essential; and what is essential is necessarily educational, if we are to live rationally.

We have confused ourselves by explaining to ourselves that we understand. We build up philosophies on subjective processes, and depart from contact with the things and the phenomena about which we philosophize and psychologize.

We are given to the use of phrases and catch-words. We have said far too much of the value of some subjects as "discipline." We make unnecessary and untrue contrasts of "conventional" and "modern" subjects; of "humanities" and "the arts" and "the sciences." I doubt

[1]Abstract of address before the Central Association of Science and Mathematics Teachers, at Columbus, Ohio, November 30.

whether the terminology represents essential differences, or means as much as we think it means.

In view of the experience in life, the effort to prove that educational values inhere somewhat exclusively in certain subjects becomes merely weariness. I think that all knowledge is good for the human mind. I have never known any education to hurt anybody, even though it is said to be poor education. Some educational effort is less effective than others because it is less organized, has less constitution, is founded on less knowledge, dominated by less sense, and propelled by a poorer teacher.

You will understand by these allusions that I am not to discuss educational values as such. Now and then we need to come back to science as science, as a knowledge and appreciation of the life we live. Here are the values that cannot be gainsaid.

I know of no line between science and non-science in education. I know of no "humanities" that are not science. I know of no "science" that is not humanities. If chemistry may be a means of effective education, so may history. Even tradition has educational value. for tradition is part of the natural history of the human race.

In this modern world of intense activity I have no fear of what we call tradition in education, although some of our writers seem to have made it a bogey-man. We might profit greatly by more tradition. It is a vast misfortune to separate ourselves so completely from the human past. We have forgotten our grandfathers and soon we shall forget our fathers.

Old subjects may be more worth while in the schoolroom than the new ones, because they carry with them much accumulated human interest; they may also be better organized as educational agencies: I should want them taught as live subjects, however, not as dead ones.

I deprecate the constant iteration of "science" and "humanities." If we were to cease this useless discussion, magnifying the differences, we should soon forget the division, for the division is arbitrary. Any subject is only what human beings make it, and of any two of the recognized subject-courses one is as humanistic and as cultural as the other were it possible for one teacher to teach the two subjects equally well. The greatest deficiency of the older line of subjects is the assumption that it is superior in itself and has more power of mental training: this attitude foreshortens the reach of the teacher and deprives him of the best approach to his pupil.

The greatest deficiency in the science line of subjects is the assumption that it is superior because it may have direct application to the arts of life: this attitude limits the range of the teacher and forestalls the full meaning of the subject. So completely do we advocate and justify science because of its application that we almost forget that the highest quest of mankind is to apprehend the truth. Recently I sat for two days hearing papers on many natural science subjects, mostly without application to current affairs. It was like a translation into a super-world, into a realm of high endeavor for the sake of the endeavor, beyond politics, commercial drives and compromises. No one paused to ask what it was for, what use it had, what anybody expected to gain by it, or what the public would think of it. I should have felt the same satisfaction had I sat for two days with a body of distinguished classicists. To state facts and conclusions because we think they are true and to let the truth be its own reward is reason enough.

This motive to know the truth and to interpret it is just as evident in what we call the humanities as in what we call the sciences. It com-

prises a reason for education. It establishes the ideals in the young, for one cannot be right with oneself or be rectilinear in relations with one's fellows unless one thinks first of the integrities rather than the expediences.

This mental attitude and the intellectual cultivation may be derived from Greek or from geometry or from biology, although the color of the result will differ with the subject and particularly with the teacher and the atmosphere of the instruction. The different subjects develop their own mental aptitudes, one, as mathematics, the integrity of the mental process, another, as geology, accurate observation. Herein lies the great value of modern education, in the fact that we may secure the central result and at the same time stimulate the variation that develops the mind sympathetically and that opens it to the vast satisfactions of life. I would not want the pupil or the student to be educated in Greek alone or in geometry alone or in biology alone.

I do not like the course of study that is all of the kind that we loosely call "the classics"; no more do I like the course that is all of the kind that we call "natural science."

It is surely unnecessary for me to say that I hold also for the full educational value of science that is applied. Science is science, whether devoted to the uses of life or whether it rests as its own reward; science does not need justification; no knowledge needs justification; it is for this reason that we should make no classification of "pure" and (by implication) "impure" science, any more than we should perpetuate the fiction of humanities and science: one is able to appreciate science for the sake of science at the same time that one applauds the application of it to medicine and agriculture. No person should ever attempt to apply scientific investigation until he understands and values science for its truth in the abstract.

We are misled by our phrases.

The speaker pointed out that the differences between the arts courses and the science courses are kept alive in part by the departmentalizing of our education, whereby each department of subject matter may become, at least in colleges and universities, a sort of an independent monarchy presided over by one king. In the larger institutions of higher learning, the great lines are separated into distinct colleges with separate and more or less autonomous administrative heads. These separations make the subjects to appear as if naturally differentiated and distinct, whereas in nature there are no such clear divisions. For administrative purposes, it may always be necessary, particularly with the growth of institutions, to separate the parts and to name them; but we should devise some way or system whereby the pedagogical aims can be brought together and one subject be brought to bear on the other. The departments in life are not as distinct as the departments in schools.

We need harmony in educational purpose rather than separation and antagonism. Whether or not we can make any change in the departmentalizing, we certainly can be careful not to suggest to the pupil that there are two camps, two realms with

divergent aims, a superior and an inferior kind of subject-matter. We can also stop all the weary discussion of "culture"; the word really contributes nothing but confusion to education. The war has shown us how dangerous it may be, in another language form as a password; we should now be ashamed to use it.

The second part of the address dealt with the place of science teaching in the development of personality and also of democratic ideas It has recently been said that the teaching of science has resulted in the deterioration of character. So far as such evils have followed, it is not that science is inadequate to the highest results in human character, but rather that we have not yet learned how to use and to teach the vast treasures of fact and application that have overwhelmed us in recent times. Science is as capable of developing the higher moral and sentimental qualities as are the older subjects. We shall understand in due time that science is not merely a handmaiden to industry, but that it may expand the soul.

The speaker detailed some of the gains in intellectual poise and outlook that may come from a good teaching of natural science in the schools and higher institutions. He founded his discussion on the statement that the purpose of the quest of science is to find the fact and to know the truth. The truth is impartial, it invites a following to the logical conclusion; therfore, it trains directly in integrity of mind. The teaching of science stands always for the open mind. The man who prejudges or who starts with personal convictions does not become an investigator. He is more than likely to use the facts of science to uphold his own egotism; this is not science, however freely it may incorporate scientific facts into its processes. Science puts out no feelers to test public opinion. It is not dogmatic. It is not partisan, if its judgment is that of the open mind, seeking the truth. Undoubtedly very much of the spread of democracy in recent time is due directly to the teaching of science, whereby persons are taught to seek the fact before they draw their conclusions.

Science is never partial to any set of facts; it knows no "beliefs"; it is free to all men so far as they are able to understand; it is unselfish; it is adaptable to all persons, fitting their needs; in the quest of science there is no secrecy, no deals, no accommodations, no conspiracy, no favor, and no courtesy to high opinion that is not founded on rational investigation; the science method is not a secret method; it removes the fear of truth and

the fear of dogma and the fear of nature. Science develops the individual, because every person makes his own investigation and takes nothing for granted. It makes directly for the independence of the voter and for stability in public opinion. It is revolutionizing agriculture; no longer do we plant in the moon and no more are we guided by the Babylonian signs. It is time to introduce into politics the attitude of the open mind, independent of party programs, to approach public questions in something of the spirit in which we approach the problems of science, desiring to know the facts, the situation, and to decide after we know rather than before The facts of science are not discovered by debate or by argument. Neither are we able to settle the tariff or any other public question by platform polemics. We need first the facts, and these are to be obtained only as the result of patient investigation by persons who are carefully trained and have no theories to establish. Without the spirit of science permeating the body politic, it is impossible to have a real democracy, for democracy is not a form of government, nor is it freedom, but a state of society that allows all citizens to partake and every one to develop his personality. Democracy cannot be bestowed; it can only be achieved.

---

## GROUP RECITATION IN GEOMETRY.

By LENA B. HANSEN,
*Kansas State Normal High School, Emporia, Kan.*

The idea of the group recitation to supplement or take the place of the usual class recitation is not a new one. It has been used by a few teachers in various forms for some time. Laboratory work in which two or more students perform an experiment together, or mathematics classes in which several students solve some problem or problems together, were perhaps the earliest forms. Groups for discussing and correcting English themes and for practice in translation and conversation in foreign languages have more recently been used with success. E. E. Dodd, Principal of the Springfield, Mo., High School, has worked out a plan for group conversation in English beginning in the junior year of the high school The teachers who have tried his plan are enthusiastic over its success.

But there is perhaps no subject in the high school curriculum in which group recitation can be used so much or to such decided

advantage as in geometry. One plan of group recitation in geometry is described by Professor S. C. Parker, of the University of Chicago, in his *Methods of Teaching in High Schools*. By this plan the class was divided into three sections according to ability, the brightest students forming one section, the medium students the second, and the slow students the third. The class was first well started as a whole, but when the members knew pretty well how to proceed and the teacher had had time to judge of their ability, then the division was made. One of the brightest students with teaching ability was put in charge of the first section permanently. A capable student from the second section was made monitor or captain of that group. Students from the two better groups were selected to take charge of the slow section for different intervals. These monitors or captains would thus be absent from their own sections a part of the time but the work missed was made up.

The groups recited at the same time in different parts of the room. Each section proceeded according to its ability; the first section completed plane and solid geometry in one year, the second completed plane, and the third about four books. Thus the good students were not held back by the slow ones, while the slow ones did not lose interest by being in a class with students with whom they were unable to keep pace. The slow students did thoroughly what they were able to do, instead of stumbling along, getting very little out of the work except a hatred for the subject. But this plan as the author says requires a very skillful teacher. The average teacher would find difficulty in keeping in close touch with, and directing, three distinct classes reciting at the same time.

A group plan which can be carried on with success by the average teacher has been used for several years by the writer. A number of other teachers have tried the plan and have reported that it has not been difficult to manage and that results were most gratifying. Three to five weeks are spent on construction work, experimental proofs, and simple field work in order to arouse interest and a demand for proofs. A few formal proofs are then taken up with the class as a whole. When most of the members know something of geometric procedure, the class is divided into groups of not more than five members in each. The divisions are not made on the basis of ability, as in the other plan, but a careful study is made of individual students, and groups are formed of those students who will probably

work well together. These groups are, however, not permanent, but are changed wholly or in part quite frequently, particularly at the beginning. Occasionally for a short period, especially when reviews are given, groups of the brightest students are formed and more difficult original exercises are given to them. Groups of boys alone and of girls alone are formed at times for variety. Greater interest is stimulated by occasional contests between the groups to see which can accomplish the most in a given time. One of the members of each group is appointed leader, but every member of the class takes his turn at being leader sometime.

After a brief meeting of the class as a whole for discussion of some point of common interest, or for the development of some new idea and for the assignment of the lesson, the groups pass to the sections of the board assigned to them and the leaders take charge. The groups recite simultaneously as in the other plan but they keep together. At first the group work is carried on only two or three days a week, and the class recitation the other days, but as the students become more proficient and better able to handle the work, recitation by class as a whole becomes less frequent. The fact that the groups keep together, however, makes the plan easy to manage. At any time that the teacher desires he can have the usual recitation for the whole or a part of the period.

Assignment of the work to be done in each group is made either by outline put on the board by the teacher, when all the groups may do the same work, or by the cards containing propositions and exercises from the text and other sources. These cards are made a part of a permanent file and are used from year to year. They are marked so that they can be quite easily sorted out to be used when needed. Sometimes the leader makes the outline for the lesson of the day with some review work which he thinks his group especially needs. The extra cards containing the original exercises are used when this work is completed.

The leader calls on each member of the group to recite, and while one student recites another may write the principal steps of the proof. The leader or any other member of the group may ask to have some part repeated if he does not think it was made clear. If any member has a different proof he is asked to give it. Students are always encouraged to work out proofs of their own for their own propositions of the text as well as for the

exercise. If a student fails he is asked to recite on the part he missed after it has been proved by another student, but he must use a different figure with different lettering. If all fail, they may work out a proof together, each contributing what he can. Sometimes very lively discussions will ensue, but this gives spice to the work. The leader must take his turn in reciting sometime during the recitation, but he can recite when he chooses so that even if the leader is a slow student he can usually find some part of the lesson with which he can do something and so is not humiliated by having to fail.

The teacher visits each group, listening, suggesting, asking questions here and there, and occasionally quizzing rapidly over parts the group has worked out in his absence. This is easily done if the principal steps of the proof are written and left until after the teacher's visit. Sometimes he may take a slow student aside for a while to help him clear up some point or he may ask some student with teaching ability for a part of the period.

The group is also very effective for out-of-door work in geometry. The instruments needed for this work are very simple and can easily be constructed by the students. Large wooden triangles, both isosceles and scalene, may be mounted on pedestals. Pins may be made, and if a good tape cannot be procured some heavy cord may be knotted in foot lengths. With these and a plumb bob a number of exercises may be worked out which not only add interest but make the students feel that the principles of geometry have some practical applications. After discussion as to methods of procedure by the class as a whole, the groups may solve problems as bisecting angles, making perpendicular offsets, dropping perpendiculars, laying off a line parallel to a line, finding the distance across a pond, the heights of buildings, computing areas of irregular plots, and other problems which will suggest themselves to the teacher. Two groups may solve the same problem by different methods, for example: one may find the height of a building by using an isosceles right triangle, another by using the scalene triangle. The next day they may explain the solution to the whole class and the methods and results may be compared.

For out-of-door work the best results are obtained by dividing the class into two or three groups. Teachers will find difficulty in supervising many groups working at some distance apart. But the smaller indoor groups may be assigned some field prob-

lems to be solved without supervision and may report results. The number in the groups for indoor work is limited to five because it was found that more than that number did not work so well. Groups of three or four work well when the class is small, but with the average high school class of thirty or thirty-five this is practically an impossible arrangement.

The advantages of the group plan over the usual class recitation plan all of the time are many. The students recite to a more interested group and hence they are more interested. They get more practice in trying to reason as every student has an opportunity every day to contribute something to the recitation. They ask questions much more freely and get the practice in thinking out questions which are usually asked by the teacher. The teacher frequently consumes too much time and the students too little. The difficulties of the student are not always appreciated by the teacher in the class recitation, for the student often tries to conceal the fact that he does not understand, in his desire to appear well before the class. The recitation is too often a period in which the student recites what he has learned for the purpose of reciting. Even if a different point is explained by a bright student or by the teacher, and the teacher asks, "Is there anyone who does not understand?" the slow student and even some good students often pretend to understand rather than to appear stupid.

The group develops the student in initiative and leadership. By making him succeed, in some measure at least, it develops confidence, for there is nothing which so much succeeds in geometry as success. Once let the student feel the thrill of really having worked out something for himself and he will work with greater zeal to succeed another time.

The students enjoy this type of recitation so much more. They feel as if they are in a big workshop. They are more directly responsible for the success of the recitation and for the success of the members of the group. The lazy student is not allowed to shirk; the members of the group insist on each member doing his part. The group recitation fosters the spirit of helpfulness and cooperation. Students have volunteered to take turns in working extra time with slow students. They discover that a student is not helped by having things told him so they become resourceful in using illustrations and asking questions which will lead him to see for himself.

The group work, however, does make a bigger demand on the

teacher, for he cannot just stand and ask questions, but must keep in close touch with all that is being done. But he comes to know his students better and to appreciate their strong and weak points better. The attitude of the class toward the teacher is more sympathetic; they feel that he is more of a friend and councilor than in the more formal recitation. The students realize that the recitation is a period of improvement and growth. Now and then some students will neglect preparing the lesson assignment before coming to class, but when this happens group privileges are taken away.

The classes using this plan have not only been able to complete plane geometry with all the exercises of a text like the Ford and Ammerman *Geometry,* but have solved many exercises from other sources. Of course all the students do not succeed equally well by this plan any more than by other plans, but even the slow students understand most of the work and solve a great many exercises. The classes have also done considerable work in out-of-door geometry besides having a number of program days. These programs, planned by different groups, assisted by the teacher, consisted of interesting bits of history, mathematical quotations, mathematical recreations, and debates on some such question as: "Resolved, That all mathematics in the high school should be elective." The programs were not confined to geometry, but interesting items from arithmetic, algebra, science, and invention were included.

Such programs may be made a big thing by giving the student a larger view of the subject. He may be given some insight into the marvelous system of the universe and learn something of the workings of mathematics in common things. He may be made to get some idea of the fertility of the human mind which through the application of the mathematical laws of nature makes our civilization possible and without which we would still be living in rude huts without our modern conveniences. This means more to him than the proving of so many theorems and exercises. However, the group recitation because of its economy of time makes it possible for the teacher to feel that he can do these things without slighting the others, and in fact through them create a stronger interest in the formal work of the class.

## PHYSICS IN THE HIGH SCHOOL.

By R. A. Burtnett,
*High School, Champaign, Ill.*

As the time for the study of physics is limited in practically all American high schools to one year, the diversified uses to which the knowledge gained in this course is to be put, the need for concentration and specialization in this subject to prepare the large percentage of college-going high school graduates for university technical courses, together with the ever-increasing subject matter in this course to be covered, especially in the field of electricity, are some of the causes which have made the thorough and adequate presentation of the subject extremely difficult.

Although four years of language are regularly taught in our high schools, and all admit that physics is just as important as language, boards have refused to consider more than one year being given to this subject, chiefly on account of administrative problems arising from the ever-increasing curricula.

Unless some rearrangement of our high school science courses and the time given to them can be made as suggested in the excellent plan outlined recently by R. A. Millikan and published in the May, 1917, issue of School Science and Mathematics, or until this plan can become formulated and placed in practice, many physics teachers may well consider what improvements they may introduce directly into their methods of presentation of this subject.

Simplification of the course as now presented may do well, for some of the most widely used books today are better as references than as texts, due to the fact that they are too profuse—made so in attempts at simplicity and lucidity—and are written by mature minds which have forgotten the workings of themselves at the ages of seventeen and eighteen. Some of the more recent texts from the press are tending too much in the opposite direction, however, are too nonmathematical, and have sacrificed too many scientific principles to make way for superfluous practical applications and illustrations.

Let the physics omit such formulas as:

$$OF = OC \times 9/5 + 32$$
$$R = K\ L/A$$
$$PV = K$$
$$\text{and } HP = f\ s/33{,}000\ t.$$

Formulas of this type are seldom really understood by the majority of a class, and their meaning would seldom be recognized

a year later. They are a hindrance to the understanding of the subject by the student and to the application of reasoning principles which the course is supposed to develop. They *may* be understood for the time being, but as such are only instruments to be remembered, and who wishes to have the student draw from his memory tools which will work only if used in the right place in preference to the application of principles which he has studied, had presented in the classroom, and verified in the laboratory? The very mental reasoning processes which a student must use in the solution of any problem carries him through the mathematical operations of the formula which has been generalized in symbols, and in which, if used, he is instructed to substitute, blindly, without any special reasoning whatever. The value of the knowledge of the principles of science lies in the complete understanding of those principles and the significance of their application, and the understanding may be made more complete by the applications to numerous and varied problems than by the single application of the principle to construct an expressionless formula to be used mechanically thereafter. All formulas cannot be eliminated from the course, and this is most certainly not desirable, but many of the above type may be eliminated, and the remainder may better be presented in emphasized lecture and laboratory form than from text assignments.

In simplifying the course the elimination of some material might be considered, yet what to eliminate would be hard to decide. Undoubtedly, in a few years we will be living under the metric system, and then most certainly the study thereof shall not be a part of the subject matter of physics, and thus some relief afforded. Not only would time be saved due to the fact that it would not be necessary to teach this system, but also much waste would be eliminated if students went into the laboratory at the beginning of the year with a thorough understanding of and complete familiarity with the units of weight and measurement which they were to use throughout the year. In after war commerce, when English-speaking peoples will be seeking to supply the markets of the world with manufactured products, the metric system if adopted would prove of great benefit. Arguments from too many points of view have recently been printed[1] to mention any further here. Metric measurements may soon come to be taught in elementary

[1]Vol. IV., No. 3, *Scientific Monthly*.

arithmetic, eliminating the necessity of time used in this study in the high school.

Every physics teacher who uses any other text than his own, and having as he does his own specialties, can better present them in a clear-cut form by lecture than by any amount or kind of assignment. This applies to the principles of the subject matter, and not to the whole body of it. Other points that the physics teacher should not neglect in his lectures are those which most authors have neglected; the welding together of the parts of the text dealing with different subject matter based upon seemingly entirely different phenomena. There should be unity and complete coherence.

With a view to this accomplishment, the following order for taking up the work throughout the year is suggested. The divisions are not to be made isolated chapters.

I. Molecular Force and Motion.
II. Mechanics of Fluids.
III. Force and Motion, Work and Energy.
IV. Heat.
V. Magnetism.
VI. Electrostatics.
VII. Current Electricity and Accompanying Magnetic, Heating, and Chemical Phenomena. Induced Currents.
VIII. Light.
IX. Sound.

With all respect for coherence, no difficulty in transition should be encountered until the end of the third division, and there certainly is the place for emphasizing the Law of Joule of heat-work equivalent. Heat and magnetism are both molecular phenomena. The electric current has been admirably defined as "an electric charge in motion, whose presence is most usually detected by the magnetic effect which it produces." This one good tie binds permanently V, VI, and VII. The heating effect of the electric current offers a further linkage with the preceding, through the relation between the electrical unit of work, the watt second, and the calorie. The electromagnetic theory of light reaches out to VIII, and the main variation in IX is the fact that there the vibratory motion takes place in the air medium.

If it can be impressed upon the young mind during the period of training in the rudiments of science that the workings of nature are based upon sets of laws which are interlinked and correlated rather than distantly related, then certainly any additional effort put forward to this end will be worth its investment.

## VALID AIMS AND PURPOSES FOR THE STUDY OF MATHEMATICS IN SECONDARY SCHOOLS.

By ALFRED DAVIS,

*Francis W. Parker School,*

*330 Webster Ave., Chicago.*

*Chairman of a Committee of the Mathematics Club of Chicago Appointed to Investigate This Topic.*

It is our purpose in making this report to aid the National Committee of the Mathematical Association of America in investigating the reasons for the teaching of mathematics in our secondary schools. The topic is a vital one, since its consideration must determine the place and the nature of the mathematics taught in our high schools. Its discussion is timely, since the challenge has come from various sources to us, as teachers of mathematics, to defend our subjects, especially algebra and geometry. Educational inertia will no longer protect us. A passive attitude is no longer tenable; we must make our position clear. Even though we have little that is new by way of argument to offer; and even though we prove nothing beyond the possibility of a question, a statement of what we are convinced is true cannot fail to be of value both to teachers and to laymen whom it may reach. Since it is desirable, if possible, to avoid every generalization not supported by the results of scientific investigation or by the highest philosophic authority, we shall, throughout the discussion, make generous use of the investigations of others and shall quote freely from those who can speak with authority. We make bold to do this because important statements and valuable work increase in importance with emphasis and use. In the words of Dr. Smith, of Teachers College, when speaking of philosophers of standing and of those who are masters in their respective fields of effort, "These after all are the men who are our leaders."

### PART I.

The study and the teaching of mathematics in our secondary schools may be justified under the following heads, and it is to these that we may turn to establish the validity of our aims and purposes:

1. *Philosophy.*
2. *Psychology and Its Experiments.*
3. *Experience.*
4. *The Utility of Mathematics*

1. Philosophers from Plato to the present time have been almost unanimous in their approval of mathematical studies. They believe that culture and mental discipline result from their pursuit. These are men to whom we must listen. They are masters in the art of reasoning and arrive at conclusions free from sentiment or prejudice. Where exceptions occur, it is usually due to a lack of knowledge of mathematics and a consequent inability to judge. The famous criticism of Sir William Hamilton has no weight, since John Stuart Mill ("Examination of Sir Wm. Hamilton's Philosophy," p. 607) shows that Hamilton did not know mathematics; and Professor C. J. Keyser (in an address at Columbia University, October 16, 1907) shows that he was prompted by unworthy motives. Oliver Wendell Holmes and Thomas Huxley were sincere in their doubts as to the value of the study of mathematics, but these have been ably answered by J. J. Sylvester and C. J. Keyser. Professor A. N. Whitehead ("Introduction to Mathematics," p. 113) says, "Philosophers, when they have possessed a thorough knowledge of mathematics, have been among those who have enriched the science with some of its best ideas. On the other hand it must be said that, with hardly an exception, all the remarks on mathematics made by those philosophers who have possessed a slight or hasty and late-acquired knowledge of it are entirely worthless, being either trivial or wrong." Philosophy's support of mathematics stands like the rock of Gibralter, secure amid the passing assaults made against it.

Plato, "Let no one ignorant of geometry enter my door."

August Comte, "No irrational exaggeration of the claims of mathematics can ever deprive that part of philosophy of the property of being the natural basis of all logical education, through its simplicity, abstractness, generality, and freedom from disturbance by human passion. There, and there alone, we find in full development the art of reasoning, all the resources of which, from the most spontaneous to the most sublime, are continually applied with far more variety and fruitfulness than elsewhere. . . . The more abstract portions of mathematics may in fact be regarded as an immense repository of logical resources, ready for use in scientific deduction and coordination."

G. Stanley Hall, "Mathematics is the ideal and norm of all careful thinking."

2. It was but yesterday that psychologists denied the transfer of training, and so to them the ability acquired in the study

of mathematics was of value only in the further study of mathematics. This position has not been successfully defended. Professor Smith, of Columbia, says, "The attack upon mathematics, that it has no general disciplinary value, has thus far been abortive scientifically. We have only to note how divergent are the results of various investigations to see the truth of the assertion." Professor G. M. Stratton, of the University of California ("School and Society") says, "It is a grave mistake to suppose that the experimental work has proved that the idea of mental discipline is no longer tenable." Today all psychologists of standing concede transfer. The only questions are as to how much, and by what agencies it is accomplished. Is it not probable that tomorrow all doubts regarding the mental transfer of training will have run their course and will be dead, at least for a time?

It would be of interest to show that questionable results have been obtained, and that undue importance has been attached to experiments worked out by psychologists and others, in attempting to show that the value of the study of mathematics has been exaggerated. Indeed, when we consider that these experiments are likely to be limited in scope; that the material to be experimented with (human minds) is almost infinite in possible variety; and that the interpretation of results is largely an individual matter; we must concede that such efforts are of doubtful value. However, psychology and its experiments in relation to the teaching of mathematics is to be considered by another committee.

3. The experience of the race justifies the teaching of mathematics. This is almost too obvious to need mention. Civilization may be measured in terms of mathematical progress. Mathematics is the ladder, giving the sure footing, by which we have climbed steadily to higher levels of achievment. It is through mathematics that man has been able to strip mystery from the forces in nature and to harness them for his service. Colonel F. W. Parker ("Talks on Pedagogics," p. 92) says, "The lower the grade of development in the human race the less there is known of number." Mathematics is then an intrinsic element in human progress. Scientific progress is impossible without it. It is interwoven in the fabric of our commercial and industrial life. Since this is true it must change as the race advances—perhaps slowly—but ever to increase the importance of its study.

4. The direct practical utility of mathematics alone will not justify our present high school courses in the subject. To many earnest and sincere critics mathematics is only a tool invented by man for the mastery of other fields. In fact, this is the rock on which most of those who object to mathematics shipwreck. Mathematics is vastly more than a tool; it is a type of thought, and even high school students gain indispensable training in mental activities from it—such training as cannot be gained so well from any other study. Professor C. J. Keyser ("The New Infinite and the Old Theology") says, "Mathematics is indeed a humble servant—a drudge, if you please; an unsurpassed drudge—in the sense that nothing else does a larger share of humble and homely work. To imagine, however, that her place in the hierarchy of knowledges is thereby defined is hardly the beginning of wisdom in the matter. It is necessary to look much higher. Her rank in the ascending scale is not that of a useful drudge, immeasurable as is her service in that capacity; it is not merely the rank of a metric and computatory art, invaluable as the latter is, as well in science as in the affairs of a workaday world; it is not even that of a servant to other sciences in their fields of experimental and observational research, indispensable as mathematics is in that regard; over and above these things, she is charged with a sacred guardianship—in her keeping are certain ideals, the ideal forms of science and the standards of perfect thinking; she is concerned not with the vagaries, but with the verities of thought, with select matters independent of opinion, passion, accident, and will; it is thus peculiarly hers to release human faculties from the dominion of sense by winning allegiance to things that abide; her meditations transcend the accidents of time and place; it is their idiosyncrasy to have for subject proper, not the fickle and transitory elements in the stream of a flowing world, but those aspects of being that present themselves under the forms of the infinite and eternal." The tendency today is to overemphasize the utility of all high school studies. Professor John Dewey ("How We Think," p. 138) says, "There is such a thing, even from the commonsense standpoint, as being 'too practical,' as being so intent upon the immediately practical as not to see beyond the end of one's nose or as cutting off the limb upon which one is sitting. . . . Exclusive preoccupation, with matters of use and application, so narrows the horizon as in the long run to defeat itself. It does not pay to tether one's thoughts to the post of

use with too short a rope. Power in action requires some largeness and imaginativeness of vision. Men must at least have enough interest in thinking to escape the limits of routine and custom. Interest in knowledge for the sake of knowledge, in thinking for the sake of the free play of thought, is necessary then to the *emancipation* of practical life—to make it rich and progressive." Lord Beaconsfield's definition of a practical man is too often the truth: "A practical man is one who practices the errors of his forefathers."

Many today make the mistake of measuring educational values in terms of money. They would prepare the child merely to get the necessaries of life. These are the enemies of liberal education; for if such are our aims we are, as a people, in the process of decay. The aim of education should be to make lives worth preserving—lives that will, at least in some small measure, make the world a better place in which to live. But multitudes of men and women "like dumb driven cattle" go wearily to toil each day. They use the last measure of strength in earning a livelihood—beyond this they have no vision. If they seem satisfied it is because they lack the outlook on life which an education ought to give. There is danger that educators will assume that people need training for efficiency *in* this sort of life, but such is not the vision of leadership. These people need the best possible education, as much of it as they can get; not an education in any sense inferior, or suited to an inferior station in life. Professor Keyser (*Educational Review*, April, 1917) says, "I desire to warn you, as a friend, against the enemies of liberal education. These are very numerous, being easy to produce, springing up like weeds along the dusty highway, almost under the very hoof of travel. I desire to warn you against the insidious and baleful influence of omnipresent, well-meaning, wingless-minded educators who unconsciously conceive young men and women as more or less sublimated beasts; and who regard colleges and universities as agencies for teaching the animals the arts of getting shelter and raiment and food." The motto of the Pythagorean Brotherhood should be the motto of today,

"A figure and a step onward:
Not a figure and a florin."

Yet the study of mathematics will ever be important from the standpoint of utility. Geometry originated in Egypt from the need to survey the farms in the valley of the Nile, and to replace the landmarks swept away by the periodic overflow of the river.

Any schoolboy knows that algebra enables us to solve problems which are practically impossible of solution by arithmetic. The invention of the calculus enabled Newton to apply his law of gravitation to the motions of the planets. As needs have arisen in various fields, mathematics have been invented to relate theory to fact. Discoveries have been made in pure mathematics, when studied for its own sake, and later these have been applied to practical ends. There are many fields in which a knowledge of mathematics is absolutely essential to their mastery; indeed, it seems to be necessary to all branches of knowledge as these become more complete and so more scientific. Dr. O. J. Lee, of Yerkes Observatory, calls attention to the fact that many astronomers, while in the opinion of the outside world successful, have failed from lack of a sufficient foundation in mathematics. The same is true of many other lines of effort. Professor J. W. A. Young ("The Teaching of Mathematics") says, "For direct practical usefulness, mathematics is second only to the mother tongue." Regarding the possible future of mathematics in this line, G. St. L. Carson ("Mathematical Education," p. 51) says, "I believe that the modern theories of pure mathematics are destined to illumine our understanding of the human mind and of cities and nations, just as the pure mathematics of fifty years ago has already illumined the previously dark and chaotic field of physical science; that modern mathematics is or will be to psychology, history, sociology, and economics as has been the older mathematics to electricity, heat, light, and other branches of physical science."

It is evident that the study of mathematics is amply justified by the testimony of philosophers who know; by its importance as an aid in mental development; by the weight of human experience; and because of its increasing utility. Mathematics is an essential part of any scheme of education that pretends to be well balanced or complete. Since the education of a rapidly increasing number of people ends with the high school, it must be taught there. What, then, may we hope to accomplish by its study?

## PART II.

The aims and purposes which may be realized in the study of mathematics are determined by its values to the one who studies it. These possible values are almost without number. We shall consider some of the more important.

1. *Mathematics Teaches Logical Thinking.*

It is the most effective means for teaching logical thinking aside from the actual study of logic; in this it is unique. Everyone needs this training and no other high school study can give it so well. John S. Mill ("System of Logic," Bk. 3, chap. 24, sec. 9) says, "The value of mathematical instruction as a preparation for those more difficult investigations consists in the applicability not of its doctrines but of its methods. Mathematics will ever remain the past perfect type of the deductive method in general." Benjamin Pierce (*American Journal of Mathematics*, vol. 4, p. 97) says, "Mathematics is the science which draws necessary conclusions." The type of reasoning most emphasized in mathematics is the deductive. This sort of reasoning is used in other subjects and is applicable to all sorts of situations in life. Deduction is the process of arriving at a logical inference based on accepted premises. Psychologists claim that all thinking is problem solving. The process as outlined by Professor Thorndike, of Teachers College, is as follows:

1. A clear statement of the goal aimed at.
2. The selection of enough and representative individual facts.
3. Their arrangement in such a way as to make the general idea or judgment to which they lead obvious.
4. The verification of the conclusion by an appeal to known facts.
5. Its reinforcement and clarification by exercises in applying it to new individual facts.

It is evident that the study of mathematics gives training in this process. The committee on Secondary Mathematics, appointed by the New England Association of Teachers of Mathematics, says, "Whatever one's occupation, it will be fundamentally important to have acquired in youth the habit of exact, orderly and logical thinking, which, if the experience of many centuries of teaching can be trusted, is best acquired by most high school students in mathematics well taught." Mathematics is, then, of first rank among high school studies in teaching pupils how to think. Its fundamental concepts are few in number, very simple, and lie close to the experience of the pupil. It should therefore be an easy study for any normal mind. John Locke ("Conduct of the Understanding") says, "Would you have a man reason well, you must use him to it

betimes. Exercise his mind in observing the connection between ideas and following them in train. Nothing does this better than mathematics, which, therefore, I think should be taught to all who have the time and opportunity, not so much to make them mathematicians, as to make them reasonable creatures. . . . In all sorts of reasoning, every simple argument should be managed as a mathematical demonstration."

2. *Mathematics Creates Self-Confidence.*

This is not the confidence that makes "fools step in where angels fear to tread"; but a confidence based on that self-knowledge, and on that self-command which give poise and power. The gaining of this confidence is a necessary part of the early education of every individual, and it can be accomplished better by mathematics than by any other study. Other subjects depend on authority, and there is usually a difference between authorities and a conflict of opinions. The student is frequently bewildered. He wonders which authority to accept, and he doubts his ability to think out a conclusion of his own. He finds mathematics different. In mathematics there is no such thing as an outside authority: given certain premises, there can be no doubt about the results of his reasoning. Results are either right or wrong and they can be checked: algebra by arithmetical calculation, geometry by actual measurement. The reasoning of a student who lacks ability to study mathematics, or who lacks training in it, is likely to be of doubtful value—he is likely to be uncertain of it himself.

If mathematics has been properly taught and thoroughly mastered, one will not place too much dependence on the opinions of others. In this way its study will make for a better citizenship. The mastery of mathematics must insure the presence in a man of those qualities, at least some measure of them, which make leaders. The success of a democratic government depends on the power of its people to think intelligently and to act wisely. Sir James Bryce says, "It is by the best minds that nations win and retain leadership. No pains can be too great that are spent on developing such minds to the finest point of efficiency." It is equally true that no pains are too great that will raise the intelligence of the mass of the people to greater efficiency. It is economy to use mathematics as a means to these ends. The life of Lincoln illustrates this. In the "Life of Lincoln," Nicolay and Hay, vol. 1, p. 229, we read: "It was at this time that he gave notable proof of his unusual

powers of mental discipline. His wider knowledge of men and things, acquired by contact with the great world, had shown him a certain lack in himself of the power of close and sustained reasoning. To remedy this defect, he applied himself, after his return from Congress, to such works upon logic and mathematics as he fancied would be serviceable. Devoting himself with dogged energy to the task in hand, he soon learned by heart six books of the propositions of Euclid, and he retained throughout life an intimate knowledge of the principles they contain." This is not an isolated case; others give testimony to the value of the study of mathematics in giving power to direct men on important issues.

3. *Mathematics Cultivates the Power of Concentration.*

The success of a student depends on his early gaining of the power to concentrate his mind on a given problem. To work with the highest efficiency the mind must be wholly absorbed with the task in hand, the nerves tense, and the body in an attitude that suggests attention and alertness. The easy-chair loafing method will not lead to a trained and developed mind. The pupil whose mind goes "wool-gathering" in the midst of important work, or who is easily distracted by his surroundings, is a failure as a student. This power to study is developed by mathematics as by few other studies. While apparent progress might be made in some studies without it, concentration is vital in this study. *The New England Report* says, "The real development of mankind lies in the growth of voluntary attention, which is not passively attracted, but turns actively to that which is important, significant, and valuable in itself. No one is born with such power. It has to be trained and educated. This great function of education is too often neglected." We are inclined to forget that real progress is directly proportional to the conscious effort of the individual. Prof. W. C. Bagley, of Teachers College, says, "Bricks cannot be made without straw, nor can mental growth be achieved without individual effort and individual sacrifice." Work is not play and the child must distinguish between the two. Something must be done besides amusing our pupils in class. There is something more important than catering to the child's wishes. Sometimes he may have duties to perform that he will not like. He needs the training that such effort will give, since he must learn to adjust himself to environment, and to the comfort and wishes of others as well as of himself.

Spencer defined the educated being as one who did what he ought, when he ought, whether he wanted to or not. The pupil must learn that the world does not revolve about himself; and we as teachers should recognize the fact that a pupil does not find himself educated without knowing how it happened. Mathematics has the power to develop concentration; and it is our duty to furnish adequate motive for the effort that will accomplish this result. Professor R. E. Moritz (University of Washington) says, "That mathematics is the most efficient agency for acquiring the power of quick attention and prolonged concentration of mind has never been seriously questioned by competent critics." Prof. Gonzales Lodge, of Teachers College (Address before the faculty of Teachers College, February 8, 1917) says, "It is apparently becoming more and more a cardinal doctrine of the shallow thinkers of the present day and generation that the mind of man cannot be trained; that the only thing that can be trained is the hand. . . . It seems to me axiomatic that mental training to be valuable must involve effort. . . . I mean that kind of effort, necessary in the development of the attitude of mind that faces a problem squarely, which goes to work at it in detail, which analyzes it with care and exactness; which expresses the results of this analysis with the same care and exactness. The mind that can do that is certainly a trained mind, and the benefits of such training are available in every walk of life."

4. *Mathematics Demands Originality in Its Study.*

It is probable that much of our school work stifles initiative and originality, if it does not kill these outright, in attempting to fashion large class groups according to one mould. This deplorable condition is aggravated by the excessive dependence on the text and the memory work so common in all studies. If the pupil can make a show of learning by repeating other people's ideas he is passed on and the teacher is counted a success. Mathematics, properly taught, and especially in its application to well chosen practical problems, requires independent thought and judgment. The pupil is able to realize all the joy of individual discovery and achievement, which is in itself a sufficient motive for the study of any subject. His new consciousness of independence and of power is an inspiration and a delight to a reasonably keen-minded student and is frequently a stimulus to a slower mind. Mathematics is usually the child's first introduction to the possibility of independent

thinking; and at a time when the independence of maturity should be developing, it is especially suited to his needs. However, it sometimes happens that a child's ability to remember and to repeat glibly is mistaken for ability to think. Consequently a "bright" pupil fails in mathematics and the subject or the teacher is condemned by disappointed parents. To say that the study of mathematics does not develop originality, or to teach it as a thing to be learned by rote and to be applied by machine methods, is to debase it to the rank of a mere tool and create the possibility that a show of learning may be made by a mere exercise of the memory. There can be little gain for the pupil in either case. J. J. Sylvester ("Mathematical Papers") says, "As the prerogative of natural science is to cultivate a taste for observation, so that of mathematics is, almost from the starting point, to stimulate the faculty of invention."

Again, some students may possess unusual abilities in mathematics or in related fields. A lack of a knowledge of algebra and geometry in early years may mean that these will remain forever buried and that the race may be deprived of an important possible contribution to its progress. Even unusual difficulties with these subjects is not always a sufficient reason for the abandonment of them. Dr. Smith (*Mathematics Teacher*, March, 1913) speaks of some of the world's greatest mathematicians as being unpromising in early years. Florian Cajori ("A History of Mathematics," p. 201) says of Newton, "At first he seems to have been very inattentive to his studies and of very low rank in school." The study of mathematics will, then, draw out the individual powers of the pupil and enable him to "find" himself. It furnishes the best measuring rod for a pupil's abilities and needs.

5. *Mathematics Trains in the Precise Use of English.*

Teachers of algebra and geometry know that students have the greatest difficulties with translation problems in algebra and with originals in geometry. Most of the trouble is due to inability to read intelligently. Reading, of course, means getting the thought. Much of the pupil's reading up to this point has been so simple as to require little effort to get the meaning, or it may have been the mere repetition of words. The pupil must be taught to dig below the surface, to properly balance statements and to get their real meaning. The pupil must also learn to express himself in a concise and forceful manner.

Definitions must be clearly and accurately stated, not a word too many, not a word lacking, just the right word for each idea. Hypotheses must be stated exactly and kept distinct from conclusions to be reached. All of this is hard work and requires much patience, but it is a worthy effort for both teacher and student. English teachers who have had the opportunity to observe are emphatic in their approval of mathematics as an aid in the mastery of English, correcting slovenliness and inaccuracy.

Much useless discussion and controversy would be avoided if the precise use of English were made a more direct aim in the study of mathematics. Professor Moritz says, "In mathematics, therefore, the student can be brought to recognize the absolute necessity of mastering the meaning of words preliminary to their use as a vehicle of thought. Half of the misunderstandings and futile controversies in active life arise from ambiguity in the use of words. . . . Mathematics has come to be accepted as the synonym for exactness, clearness, certainty." Perhaps in no other field is this training more essential than in the practice of law. Demonstrating before a class and answering questions from teacher and fellow pupils gives self-possession, ability to think on one's feet, and the power to adjust in proper order the important parts of any problem, giving to each its proper weight, so that desired ends may be attained. The pupil thus acquires ability to discuss a problem intelligently before a critical audience. Thomas Jefferson was of the opinion that, "mathematical reasoning and deductions are a fine preparation for investigating the abstruse speculations of the law."

6. *Mathematics Trains in Accuracy.*

Probably no other subject demands this quality to so great a degree. There is no opportunity to cloak errors with results "nearly" right. If approximate results are sought the limits for the errors are known. Pupils can judge for themselves and make their own corrections. Again, carelessness in securing data or in the drawing of a figure may vitiate the whole problem, no matter how perfect the reasoning. Furthermore, neatness is an essential part of accuracy and both should be conscious aims of both teacher and pupil. They should be emphasized more than at present in our teaching of mathematics.

(To be continued)

## HOW SCHOOL GARDENS TEND TO DIRECT A NATURAL COURSE IN BOTANY.

By Genevieve Monsch,

*Froebel School, Gary, Ind.*

(*Continued from January number*)

### Sixth Week.

Because of their intense interest in their gardens, these children were always ready to talk seeds, seeds, seeds, and from the very beginning they were expressing their wonder and their surprise to find how much "a little lifeless seed" could do. They were constantly interested in watching the bees and the butterflies about the lilacs and the hyacinths, and they were constantly reminded of the story of pollination. It had become a habit early in our work to search for the pollen and the pollen boxes, the immature seeds and seed boxes in every flower available, and they were exceedingly delighted when one of the boys had finally discovered both pollen and seeds in such bisexual flowers as the willow and the strawberry after the class had begged for a week or more to be told about them. The morphology of the flower with the functions of each part was one of the easiest things that I had to teach in this course, simply because, I believe, the class was ready for such work. They had come in contact with such a large amount of material which had illustrated over and over again, pistil, seed box, seeds, pollen and pollen boxes, petals, sepals, etc., that they could enter into very intelligent discussions of the work. Even the subject of fertilization was not beyond these seventh grade youngsters although I will admit I *have* sometimes found it beyond high school pupils, and I have even known some college botany students who do not have as clear an insight into these processes as this little class had. I attribute it entirely to the interest these little people evinced in growing a few vegetables and flowers for their own use, because this very interest and the work itself brought them into daily contact with a large mass of living material.

### Seventh Week.

Seed Dispersal. (Field trip.)

1. Wind
   - Downy seeds—old cat-tails, milkweeds, etc., dandelion, willow, poplar.
   - Winged seeds—maple, parsnip.
   - Small seeds—ferns, violets, lettuce, carrots, portulaca, pigweed.
   - Tumble-weeds—whole plant carried.
2. Animals
   - Burrs.
   - Acorns and nuts—sprouting or stored.
   - Berries—strawberries, old rose-hips, etc.

3. Water { Water plants. / Algae spores. / Land plant seeds.
4. Discharge { Touch-me-not. / Violet and pansy. / Castor bean. / Witch-hazel. / Wild bean. / Primrose.

Freezing Action on Nuts, Wild Cucumbers, etc.
Why best to plant wild cucumber seeds, etc., in fall?

## Seventh Week.

The subject of seed dispersal was approached principally through their fight against weeds, which of course were constantly bobbing up both in the gardens and in the grass and among the shrubs of the school park and, of course, everywhere else. *Our* worst weeds are dandelions, milkweeds, wild lettuce, tumble weeks, potentilla, burrs, pigweed, primrose, etc., and if you take the trouble to look at this list carefully you will see that it covers the principal methods of seed distribution. Moreover, we have preserved in large jars at least a hundred different kinds of seeds, most of which are garden seeds but many of which are weed seeds, treasured up for just such times as these. To these were added specimens of seeds and fruits brought in by members of the class. Some of these specimens (cat-tails, burrs, rose-hips, tumble-weed, fruiting-fern, etc.) were remains of the year before, while others (dandelion, willows, etc.) were just maturing, and scattering their hordes of seeds.

### Eighth Week.

I. Field Trip to Study:
   1. Hydrophytes:
      a. Submerged entirely—spirogyra, mesocarpus.
      b. Submerged partly, or swamp-plants—cattails, iris.
      c. Free floating—marsh-marigold, cress, utricularia.
   2. Xerophytes or drought plants—cactus, pteris.
   3. Mesophytes or ordinary land plants, such as all those in school gardens and school park.

II. Water in Soils:
   1. Free water (swamps, etc.).
   2. Water of adhesion (mesophyticareos).
   3. Capillary attraction (experiment with lamp chimneys).
   4. Tillage. (Why so often?)

III. Uses of Water to Plants:
   1. Absorption.
   2. Germination.
   3. Conduction.
   4. Transpiration (transpiration experiments).
   5. Water storage—cactus, bulbs, sphagnum moss.
   6. Currents of water distribute seeds, spores, bacteria, whole algae, etc.
   7. Prevention of floods by forests.
   8. Photosynthesis, digestion, assimilation.

Note: Amount of water in soil is to be emphasized here. Splendid place for studying general adaptations to extreme conditions!

## Eighth Week.

Certainly it is not necessary to dwell upon this work of the eighth week. We are fortunate in having large, interesting swamps and hot, sandy, arid regions within a block of school. The children are very familiar with these regions, for they are typical of the whole of Gary, and "water plants," "drought plants," and "medium plants" are all well known and most eagerly described, and easily classified according to habitat. We had just one field trip for this subject but we were sure to include in our indoor discussion the retentiveness of soils regarding water, as well as questions of free water and water of adhesion, capillary attraction in soil, etc. This brought up the question of tillage again and of dry mulches, etc., and then, because we still had time, we discussed the uses of water to a plant, and on the blackboard we worked out the diagram shown above.

### Ninth Week.

Roots:

1. Water roots—bulbs, cress, cuttings.
2. Prop roots—corn, palms.
3. Clinging roots—English ivy, ampelopsis veitchii.
4. Air roots—orchids.
5. Soil roots:
   a. Tap roots—carrots, cabbage, radish, pigweed.
   b. Fibrous roots—clover, grass, corn, peas, onion.
   c. Clustered roots—dahlia, sweet potato.
6. Parasitic roots—dodder.

Functions of soil roots, water roots, etc.?

## Ninth Week.

The work of the ninth week is so simple that the outline shown here must explain itself. Cuttings of coleus, oleander, wandering Jew, etc., are constantly standing in the laboratory, and their delicate, interesting water roots are constantly questioned and discussed. Water bulbs are purposely dragged over until June. Water roots may have been a new subject in class but certainly it was an old subject in each individual's experience.

On the school building we had English ivy, Virginia creeper, and ampelopsis veitchii just starting up the walls, so that clinging roots were never confused with tendrils, as is often the tendency in classes of elementary botany.

Soil roots needed little explanation with this section of children. They had separated and planted over a bushel of the fleshy clustered dahlia roots and had eaten dozens of the tap roots of radishes from their own gardens and had carried on a constant warfare against weeds that were illustrating either tap

or fibrous roots. Children see these things, and when properly interested will continually carry on their investigations of their own accord.

Fortunately for the botany teacher who deals with parasitism, we have loads of dodder all about us, usually infesting the willows of our woods, and twice they have caused a great deal of damage in some of our most beautiful beds of nasturtium. All of these children know dodder and all of them can tell you how its parasitic roots bore down into another plant to steal food which it cannot manufacture for itself.

Air roots are always strangers to most of these children. Some few children who have visited Lincoln Park can tell about the roots of the orchids that have been pointed out to them there, and then there are always pictures for the rest to see. That is the best we can do, but there is an intense interest here because of its relation and association with the other types of roots with which they are so familiar.

**Tenth Week.**

Stems:

I. Aerial stems:
   1. Climbing:
      a. Twining—honeysuckle, wistaria, morning glory.
      b. Tendrils—wild cucumber, peas, ampelopsis cinquefolia.
      c. Suckers—English ivy, ampelopsis veitchii.
      d. Petioles twist—clematis, nasturtium.
      e. Thorns—rose.
   2. Prostrate stems—wandering Jew, melons, strawberry runners.
   3. Erect stems:
      a. Branched—trees, bushes.
      b. Unbranched—sunflower, corn, canna, golden rod.

II. Underground stems:
   1. Bulbs—onion, tulip, etc.
   2. Tubers—potato, Mexican potato.
   3. Corms—gladiolus, crocus, Jack-in-the-pulpit.
   4. Rootstocks—violet, fern, lily-of-the-valley, square stem of mint.

## Tenth Week.

If you look carefully over this outline for this tenth and last week's work you will see that it deals only with such material as the children have been dealing with and working with for ten long weeks—material which has become to them as familiar as the very members of their own class. Moreover, the garden displays all of this material in large numbers. For instance, all of the climbing and the prostrate stems mentioned, and many others besides, are found over and over again in our school gardens—all except the clematis, of which we have but two large vines. The underground stems, too, had been planted

and were growing in large quantities. Hundreds of onions had been planted and grown and eaten and numerous crocus-corms and Dutch bulbs of all kinds had been removed. About two hundred corms of gladioli, a half-bushel of potato tubers, two bushels of the fascicled roots of dahlia, dozens of lily-of-the-valley root stocks and Mexican potato tubers had been handled. That is the only reason why this work seemed so simple to these boys and girls.

## Conclusion.

**Sequence in Textbooks.**

Seeds and Flowers.

1. Morphology of flowers.
2. Pollination.
3. Fertilization.
4. Seeds (and fruits).
5. Seeds:
   - a. Embryo.
   - b. Monocotyledons or cotyledons
   - c. Kinds of food (reserve material).
   - d. Seed coats.
   - e. Conditions for germination (temperature, moisture, air).
   - f. Types of seedlings:
     - Dicotyledons:
       - Cotyledons underground—pea, oak.
       - Cotyledons above ground—bean, squash, morning-glory, radish.
     - Monocotyledons:
       - Cotyledons as well as coat brought above ground—grains.
       - Cotyledons left in the soil.
       - Larger grains left in soil—corn, date.
6. Seed distribution.
7. Struggle for existence.

**Sequence in Actual Gardening.**

Seeds and Flowers.

1. Child receives seeds (5 to 17 kinds, small, large).
2. Plants them (cultural directions, requirements for germination).
3. Energy of seed (growth, force in cracking soil).
4. Kinds of food in different seeds:
   - Oils in peanuts, castor-oil, corn.
   - Proteids in beans, peas, corn.
   - Starch in corn, etc.
   - Sugar in corn, peas.
5. Hypocotyl arch, cotyledons, plumules, roots (embryo).
6. Seed coats above ground and discarded.
7. Seed coats, etc., below ground.
8. Roots (underground). Types of roots.
9. Structure of seed: embryo, food, coats.
10. Seeds always in fruit. Fruit always from flower.
11. Find fruit and seeds in flowers (tulips, lupine blossoms of pea, fruit-blossom).
12. Pollination.
13. Morphology of a flower.
14. Fertilization.

In conclusion, I would just like to point out the difference in the sequence in a course in botany founded directly and entirely upon garden work, such as the one I have described, and the ordinary textbook work. Take the subject of seeds and flowers, for instance, and note the sequence which I have contrasted in outline form. Note that the morphology of the flower, for instance, is placed first in one outline and last in another. Moreover, as I read down the list of topics in the garden sequence, I realize that there was never an instance where this information

had to be administered in "capsular form." Because of numerous contact experiences through his garden work, the child was always more or less familiar with a topic long before it was handled in class, for the topics were continually bobbing up before them in the garden day after day, in one way or another. In practical individual garden work, it is next to an impossibility to study a subject carefully and thoroughly one day and then to "salt" it and lay it upon the shelf for the test at the end of the month, as we can do so successfully in science courses that do not have the practical work for a basis. I know because I have taught under both systems.

Whether this always is the best way to teach the principles of botany or not in the seventh and eighth grades I am not in a position to say. In my own case, however, I am sure that I have never given a course which has seemed so delightful and so satisfactory. The enthusiasm of the class never lagged. They had a project that they were working for. Their whole aim was, of course, to raise vegetables and flowers, and they were always eager to find out all they could about the science of vegetables and flowers. They were always happy and busy, engaged not only with the mere physical drudgery of working the spade and the hoe, but with deep mental problems concerning their work. This was shown by their conversations with each other and by the hundreds of most intelligent questions that were constantly being asked.

It is not at all the easiest course in the world for a teacher to give, for she must be the spirit back of all of their enthusiasm and back of their observations, and she must often very skillfully be ready to present the opportunity for a little research work, and then so quietly withdraw from the field that the child has the whole pleasure of discovery to himself. Moreover, she must have patience to help the individuals as the occasions arise, which often means explaining the same subject much oftener than by the old class method. However, in spite of all the hard work the teacher is constantly rewarded by the interest and by the intelligence of the pupils, and the pupils, on the other hand, receive their reward when they proudly carry home their onions or their pansies.

## REMARKS ON PSYCHOLOGICAL INVESTIGATIONS BEARING ON THE DISCIPLINARY VALUE OF STUDIES.

By J. W. A. Young,
*The University of Chicago.*

In a preceding paper (pp. 1-10, Jan. 1918), I gave a very brief summary of the experimental work done by psychologists on the transfer of training, leaving the discussion and interpretation of the material to the reader. In what follows, I give a few disjointed fragments of my own theorizing on the question of the disciplinary value of studies, especially of mathematics, and of my reactions to the first-hand literature of the work done by psychologists and to the misunderstanding and misinterpretation of this work in wider nonpsychological circles.

I. One of the chief reasons why mathematics should be studied by all is that it exhibits the best and most convincing type of proof known to the human mind. Mathematical certainty is the most satisfying certainty; the mathematical proof is the ideal of all seekers after truth. Every science consciously endeavors to approximate to the mathematical type as closely as the nature of its materials will permit, and measures the reliability of its results by the closeness of the approximation. Every pupil, girl and boy alike, should be shown this type of proof and given practice in it until he has grasped and assimilated something of its spirit. The pupil will of course gain little unless the ideals of mathematical proof function beyond the confines of mathematics.

The expectation that the ideals will so function is based largely upon myriads of practical experiences like the following by one of the experimenters of our list, experiences that are at least as significant (to put it mildly) as counting dots or crossing off a's. W. C. Bagley[1] "is convinced that students who come into his class in psychology after completing thorough courses in the higher mathematics do far better work than those who have not had this 'training.' Something has been carried over from one study to the other. It is certainly not the *habit* of study, nor are the points that mathematics and psychology have in common sufficient to account for the difference."

But in the present paper, no more overwhelming instance of effective and valuable functioning of mathematical ideals in a large and important nonmathematical field could be adduced than the stately edifice of modern laboratory psychology itself. If one had to differentiate the newer psychology from the old

[1] *Educative Process*, p. 211.

in a word, it would be hard to do so better than by saying that the new psychology aims to work by exact measurements and to interpret the results in the mathematical spirit.

To read modern psychological literature with ease, and particularly the publications that bear on transfer, one must have a certain degree of familiarity with mathematical terms and methods. One finds plenty of tables, graphs, and curves, and quite a sprinkling of formulas. To a superficial observer the books look quite mathematical, and to a closer reader the dominance of mathematical ideals of proof is evident. See, for example, Thorndike's *Educational Psychology*, or Whipple's *Manual*. Modern psychology itself is a monumental instance of transfer of mathematical ideals and thought-processes.

II. The edifice of experimental psychology has as one of its foundation stones the assumption that the same mental powers function in varying situations, that mental strength can be transferred from one activity to another and more or less different one. This is quite evident when we consider how psychology, following the example of mathematics, endeavors by making situations abstract, simple, and artificial, to control them more completely in the laboratory than can be done in everyday life. But who that does not believe that *the same* mental powers are applied in the more complex situations of real life as in counting dots or crossing off a's would stultify himself by professing to test an individual's mental capacity at any given time, or to measure his mental growth from time to time by his success in counting dots? If anyone finds the situations of mathematics artificial and unrelated to real life, how much more so are those of the psychological laboratory. Truly, the child has outdone its parent! The facts of mathematics have a high content value, but what is the content value of counting dots or memorizing nonsense syllables? Having no content value, what other value can the laboratory tests have than to give information as to how the mind would function in the complex situations of everyday, nonlaboratory life? The very existence of an organized body of such laboratory tests as are described in Whipple's *Manual* voices the belief of its users in the applicability of the powers tested under circumstances that are superficially very different from those of the test.[2]

[2]When I say that the existence of the mental tests currently used implies a belief in transfer, I do not refer to the thirty experiments on transfer enumerated in the list of my previous paper. These were undertaken for the purpose of ascertaining whether or not there is any connection between the particular activities tested, and the experimenter does not by implica-

III. Not only does the character of the psychological work presuppose belief in transfer, but the frequent use of computation to investigate mental powers that are superficially quite different from computation must needs rest on the belief that the powers applied in these various fields have something of consequence in common with those used in computation. Thus Whipple tells us (p. 461), that the computation test has been employed not merely to study associative processes, but also for the more general purpose of investigating mental efficiency at large. Computation tests have been used to study individual differences in the nature of associative processes; to study the correlation of specific mental functions; to determine the relative influence of heredity and environment upon mental efficiency; to compare the ability of normal, paralytic, and hebephrenic children; to investigate the effect upon mental efficiency of posture, of distraction, of caffein; to investigate the transfer of special drill. "But the commonest application of the computation test has been made in the formulation of the curve of mental efficiency, of the work-curve, with special reference to the influence of practice, rest-pauses, exercise, and similar factors upon the mental efficiency of adults, and especially of children during a school day." In Whipple's *Manual*, the names of the investigators making the tests are given; in all, forty-four names appear, including repetitions.

IV. The term "formal discipline," or "doctrine of formal discipline," is much used by nonpsychologists and occasionally by psychologists, but always by writers who are disclaiming adherence to the doctrine. I have never found the term used and the doctrine defined by a professing adherent of it. Even opponents seldom set up a careful definition of the doctrine, and when a definition is set up it is done with the avowed purpose of knocking the doctrine down, which operation is then immediately performed to the entire satisfaction of the operator.

tion commit himself to any attitude on that matter. But when ability in memorizing nonsense syllables is used as a yardstick in educational work, or to help in vocational guidance, then it is obviously assumed that *the same* memory which is applied to nonsense syllables is also applied in other school work and in vocational activities.

The tests to which I do refer are those of the type listed in Whipple's *Manual*. These give a far more adequate picture of the psychology of today than the thirty constituting "all the work on formal discipline." Hundreds of titles are entered in Whipple's bibliographies, and the tests described in his work are of the same general type as those in our list.

The underlying assumption of which I have been speaking is put into words from time to time by psychologists. Thus Whipple (p. 3):

"Outside the laboratory an active and very natural interest in mental tests has been exhibited by those who are busy with practical problems to the solution of which the scientific study of mind may be expected to contribute. It is naturally the educator to whom the development of a significant and reliable system of mental tests would most appeal, since he is concerned with *the development of just those capacities of mind* that the tests propose to measure. . . . Of late, too, hopeful beginnings have been made in application of mental tests to vocational guidance, whether in the selection of people for positions, or the selection of positions for people." (Italics mine.)

But the reader is driven to ask: "Was there ever anyone who seriously held this prostrate doctrine?"

Thus Heck defines (p. 160): "The doctrine of formal discipline, in its extreme form, implies that the mind is made up or possessed of certain general powers or faculties—memory, imagination, reasoning, etc. These powers are developed by exercise to a degree proportionate to the force and duration of the exercise taken . . . This development . . . of the power involved can be used in response to any other stimulus . . . with little change in nature or diminution in amount. The different powers are considered like different tanks or reservoirs with many pipes emptying into them and many draining out of them. No matter through what pipe water gets into the tank, it can go out by any other pipe and continue almost unchanged through the entire process."

And Bagley (*Educ. Process*, p. 203): "For example; a pupil may acquire the habit of producing neat papers in arithmetic. The doctrine of formal discipline assumes that if this habit is once thoroughly established it will function *equally well* with language and drawing; that functioning successfully here, it *cannot fail* to insure neatness of person and attire; and that the neatness thus ingrained upon the pupil will *surely* be carried over into mature years." (Italics mine.)

Again one is driven to ask: "Who ever held such views?" The few specific citations that I have found of passages supposed to advocate the "doctrine of formal discipline" are far from sufficient to convince me that their writers hold the views just quoted. And some of the attempts to prop up a man of straw to be demolished would be ludicrous if they were not so pathetic. Because, in common parlance, a man may be described as an acute thinker, a shrewd observer, a lover of the beautiful, fond of history, or courageous without always specifying in what subjects he is an acute thinker, of what sort of beautiful things he is a lover, in what phases of life he is courageous, whether in fighting, in facing an audience, or in facing a woman, or of what sort of history he is fond, or in what lines he is a good observer—it by no means follows that all who use these expressions believe that mental power is a sort of entity that can be turned in any direction at will and applied equally well to the solution of any problem, or, that they believe that there is only one sort of courage, or of acute thinking, or of shrewd observing.

V. One investigator has discovered that quickness in arith-

metic and quickness in marking misspelled words are not necessarily associated. That is, there is no "general" power of quickness. Anyone who has believed in the existence of such a power (though to me the existence of such a believer is mythical) will of course find little comfort in this "discovery." But it is a far cry from this to the assertion that none of the types of quickness which can be trained in the study of arithmetic will function elsewhere.

Some one might conduct a series of experiments to ascertain whether or not quickness in dodging automobiles is necessarily associated with quickness in repartee. One would expect the outcome to be that it is not. And in case the experiment does in fact turn out as common sense would lead one to expect that it will, why should one infer from this result that no training is of any value outside of its own field, that one always learns specific facts and nothing more, and that every subject should be studied for its content merely?

VI. The nonpsychologic reader on this subject must be sure that he understands what is meant if he ever finds a careful psychologist expressing the opinion that this or that specified power cannot be strengthened by training. The meaning may give no support whatever to the view that there is no *gain* from training. The gain may exist but, in the opinion of the psychologist, what produces it may not be technically increased strength of the power in question.

Thus James[3] expressed the view that memory could not be strengthened by training, though he admitted that we could learn by practice how to use more effectively the memory powers with which we are initially endowed. That is, memory is not like a muscle that is strengthened by training, but like a tool that we learn to use better.

One may admit all this, and yet not modify his views as to the desirability of "memory training" or the methods of accomplishing it. Experience has shown that in certain ways we can succeed in *remembering better*. Whether we say that this is done by a strengthened memory or by a better use of an unstrengthened memory is, from the point of view of everyday schoolroom practice and needs, largely a matter of words.

[3] "No amount of culture would seem capable of modifying a man's general retentiveness. This is a physiologic quality given once for all with his organization and which he can never hope to change.

"All improvement of memory consists then in improvement of one's habitual method of recording facts. Native tenacity is not a whit improved. It is a case of better remembering by better thinking. The improvement will, I am sure, be always found to reside in the mode of study and not at all in any enhancement of the brute retentive power." James, Wm., *Principles of Psychology*, Vol. I, pp. 663, 667.

VII. The experiments thus far made seldom duplicate each other, or even test the same abilities. If any revolution in the world's thought as to transfer is to be warranted by experimental results, the same experiment must be repeated many times with concordant outcomes. Even simple physical experiments, whose results are foreknown with quasi-mathematical certainty, are repeated hundreds of times in our physical laboratories. A thing has not been proved experimentally unless the experiment has been frequently repeated with uniformly the same result. Consider, for example, the experiment which examines the falling of a bullet and a feather in a vacuum, and which exhibits the two objects falling one about as fast as the other in an approximate vacuum. If this were a laborious and complicated experiment, and if it had been done only once in all the world; if in that one trial there had been many possibilities of vitiating influences; would or should any physicist reverse or even modify his views of the law of gravitation in consequence of this experiment alone? Even if the results of this one experiment were to point definitely in the direction of a modification of his views (and we have seen that the trend of the experimental results on transfer is affirmative and not negative), would he not demand that first of all the experiment be repeated over and over until all irrelevant and disturbing factors had been eliminated and the essential outcome and meaning of the experiment fixed beyond peradventure?

VIII. The experiments usually show about that measure of transfer which it seems to me common sense and experience would lead one to expect. A few show less, and a few show more. Thus, I should not have expected (Experiment VII) that practice on memorizing the order of four tones would cause improvement in the memory for poetry or for the order of four shades of gray. But psychologists are not yet in a position to give expert verdicts or anywhere near it. Psychologists of high rank are the first to recognize this, and to deprecate the impression that has gained currency among the less well-informed to the effect that psychology has *settled* the general problems in this field. Thus Whipple (pp. 3-4):

" . . . there has been, unfortunately it seems to us, a disposition in some quarters to speak as if a science of mental tests were already achieved; . . . To make such assertions is surely misleading, for . . . there is at the present time scarcely a single mental test that can be applied unequivocally as a psychical

measuring rod. The fact is we have not agreed upon methods of procedure; we too often do not know what we are measuring; and we too seldom realize the astounding complexity, variety, and delicacy of form of our psychical nature."

IX. Coover in an extensive recent study* gives a general survey of the field, a detailed account of his own experiments and an extensive bibliography. In summing up, he says (pp. 234, 241):

"Evidence from the literature of experimental psychology indicates a functional relationship between various mental processes. . . . Under experimental conditions the 'general' effect usually ranges, in amount, from one-fourth to three-fourths of the gain made in specific practice. . . . The contribution (of experimental research in the psychological laboratory) is important in that it shows the general effect of special practice; but it is limited in its scope to fairly simple processes, to periods of short training, and, for introspection, to reagents upon whom training does not produce great practice effect. Were the processes as complex and various as those engaged in the study of Greek, mathematics or science; were the training extended over four school years instead of ten weeks under limiting laboratory conditions; and were the subjects in the plastic period of the 'teens,' it is conceivable that the extent to which the training is general would be found to be greatly in excess of the laboratory figures."

Few of the experiments of the list in my previous paper studied the effect on a large number of persons, of work in a given branch of study for a considerable length of time under ordinary classroom conditions. This is, of course, what the educator needs chiefly to know. In this respect, the experiment of Rugg (XXX) is by far the most satisfactory of the list and indicates a line along which further experiment is desirable. It is difficult to conceive of a broad educational thesis as conclusively *proved* experimentally until it has been repeatedly verified under classroom conditions.

X. My conclusion as to the whole matter is that in the psychological experiments we have a body of minute work spread very thinly over portions of an enormous field; that the work is markedly heterogeneous as to method, thoroughness, and standards of scientific accuracy; that even within the range of the experiment itself the results are often by no means conclusive,

---

*Coover, J. E., Formal Discipline from the standpoint of Educational Psychology, Psychological Monographs, No. 87. Princeton, N. J., 1916, pp. viii+307.

and that the sum total is as yet far from constituting a scientific proof of any general thesis.

Let me illustrate by a specific example.

In Foster's experiment (No. XVIII), three adults (two doctors of philosophy, one university instructor of psychology), all evidently fully matured men with well-established mental habits, practiced forty hours in reproducing groups of dots, irregular polygons, nonsense and sense drawings and objects. They believe, on the basis of introspection, that their "power of visualizing" was not strengthened. Was it even trained? They were allowed to follow lines of least resistance. After the practice, they were able to do that type of task better. No test is reported aiming to ascertain whether or not they could do analogous tasks better; there was no untrained "control group" with which to compare the practiced group. We have only the opinion of the experimenters (introspectively attained) that this practice did not make them "noticeably better observers or memorizers in general, or give them any habits of observing closely or reporting correctly, or furnish any ability to meet better any situation generally met with" (p. 21).

Who expected that it would? Who has ever expected that copying dots would equip one to deal better with "situations generally met with," such, let us say, as running an automobile, writing a business letter, or deciding how to vote on the tariff?

And on the question of whether or not young children, with unformed and rapidly developing habits of visualization, should be taught drawing in school, the experiment seems to have nothing to say. Still less does it warrant teachers of Latin, physics, or mathematics in passing along the awe-struck whisper: "Psychology has pronounced the verdict! Our subjects give no valuable training. What value they have lies exclusively in their content."

The psychological researches that have been made are valuable but they are as yet mere scratches on the surface of a field that needs to be mined deep. Mental acts at their simplest are complex. Good psychologists would be the first to tell us how little has as yet been done in the direction of reaching an ultimate analysis of these complexes, or in the direction of determining to what extent the psychic powers at work in different mental acts are the same.

Meanwhile, the work of education must go on as best it can on the basis of common sense and the accumulated results of

daily experiments in the classroom laboratory by the teachers of today and their predecessors throughout the ages. Accurate results of research in all fields will be welcomed by the progressive teacher, and their definite indications followed out, but he will ask that the results and indications *be* accurate and definite. As far as possible he will get his information at first hand, that is, from the publications of the original experimenters. In so far as he cannot do this, he will ask at least that those who bring him the information should have themselves obtained it at first hand, and that they give specific reference to the original sources, and that they make clear distinction between the results which they report and their own interpretation of these results.

To one who will not conform to this reasonable requirement, but who offers merely vague, sweeping, unsubstantiated generalities, the wide-awake teacher will pay no heed, but will go on in the even tenor of his way, doing his utmost along the lines that have given the best account of themselves under the practical classroom tests of the past. He will strive to keep an open and progressive mind, realizing that the surest and sanest progress will be made by careful and gradual modification of the existent structure, and he will not be carried away by the rhetoric of those who wish to tear down the edifice that now houses us educationally (at least tolerably, even though far from perfectly), before a new and better edifice has been built for us to occupy.

If anyone would ask us to change our beliefs or our practices, it is obviously his duty to present and prove reasons why the change should be made. This every good psychologist is willing to do, and nothing is more characteristic of the writings of psychologists, seen at first hand, or their expressions of views face to face, than their evident aim to state all the facts fairly and clearly, and to claim as proved no more than the results of investigation will warrant. The results reached by psychologists working in the scientific spirit, when received and interpreted in the same spirit, can do only good. But danger lies in the accretions and distortions that the descriptions of these results undergo when handed down the line from science to rhetoric, from first to tenth hand.

## SANITARY SURVEYS CONDUCTED BY STUDENTS.

By F. E. Chidester,

*Rutgers College, New Brunswick, N. J.*

In connection with the study of hygiene and sanitation in schools and colleges, it is most desirable that the student be given practical experience in the field. It is possible by interesting the young people of a community in actual conditions to so awaken the adult that some good may result. A survey may consist either in a general study or in a specific study which includes house-to-house inspection. An outline which has been found valuable in making surveys of smaller cities not completely provided with sewerage systems follows:

### Location and Population.

First of all one must learn of the provision for natural drainage. It is important to learn not only the elevation of the town and its relation to streams, but also to know the character of the soil and the rapidity and direction of the seepage. A study of the population will indicate almost immediately the living customs which predominate.

### Buildings.

In addition to a study of the houses and outhouses, it is of utmost importance to learn the distribution of barns and stables, which are so important in the production of the typhoid fly and other injurious insects. A study of the factories will often disclose almost unbelievable insanitary conditions. The production of wastes from certain manufactories and the ultimate disposal of such wastes is also extremely important. In smaller cities where complete sewerage systems do not exist, the disposition of outhouses is of the utmost importance. In the majority of the smaller cities it is usually found extremely difficult to enforce the law regarding depth of pits and the relative positions of the outhouse and the well. In some of the foreign districts of a city one may find a community well into which drain numerous cesspools.

### Streets.

The condition of the streets and the establishment or enforcement of ordinances regarding care is often of the greatest importance even in comparatively small municipalities. Sprinkling or oiling streets is often feasible in small towns not able to engage in paving.

### Sewerage.

In cities which have well-constructed sewerage systems, one

often finds the outlets to be in a stream so near another municipality as to seriously jeopardize the health of the receivers of the waste.

### Supplies.

#### *Water.*

Municipal water supplies are often much more carefully examined and regulated than are the numerous wells and cisterns which are privately owned. Another source of disease is the improperly regulated spring water distributor.

#### *Ice.*

Ice may be beautiful in clearness and yet may be taken from pools which contain animal waste. Drivers of ice wagons are known who invariably wash the ice with water from a city horse trough. The danger of anthrax and actinomycosis is well known, while from the aesthetic point of view much is to be desired. Artificial ice is without question far superior, but even here the possibility of disease transmission is considerable.

#### *Milk.*

Milk, as is well known, may be of the very highest quality, and yet contamination by one or more typhoid carriers may produce serious epidemics. Nonenforcement of the law regarding sterilization of bottles is also likely to exist.

#### *Bread.*

Among the greatest offenders against the health of the consumer are the bakers. In many cases bakeries are situated in basement rooms, and the bread is exposed to flies and other disease-bearing insects. Even today one finds cases of unwrapped bread packed in a dirty wagon and exposed to street dust.

#### *Vegetables and Fruits.*

Vegetables which are grown by people of certain nationalities are fertilized with human feces, and if insufficiently washed before coming to the table may be a cause of disease transmission. Likewise, fruits, such as bananas, ripened in the cellars or sleeping rooms of the dealers, may carry large numbers of disease germs. The exposure of fruits and vegetables uncovered may also result in acquirement of considerable disease-bearing street dust.

#### *Meats.*

In the large cities where all meats come from slaughter-houses inspected by Government veterinarians, one need suffer little apprehension regarding the health of the animal. It is in the

smaller cities and in the villages where unregulated slaughter houses exist that one finds diseased animals most numerous. The after care of meats while hanging in the storehouses or in butcher shops also demands considerable attention. In too many cases does one find that meats are exposed to flies for several hours of each day.

*Candy.*

Candy factories run on a small scale are often extremely dirty. Closer supervision of manufacture must exist before the introduction of injurious ingredients in cheap candies can be eliminated.

*Soda Fountains.*

Some of the most flagrant violations of the law and of common decency exist in soda fountains situated in apparently respectable drug stores and lunch rooms. In comparatively few cases does one find that the glassware is sterilized after use. In the majority of cases one sees rinsing in dirty cold water to be the only means of cleaning.

CARAVANSARIES.

Students have no difficulty in obtaining admittance to the kitchens of hotels and restaurants. In fact the proprietors are afraid to forbid them entrance. Without question the fear of inspection itself is sufficient to cause general clean-ups.

JAIL.

It goes without saying that even high school students should visit courtrooms and learn the procedure. It is also of considerable importance that the community should know the conditions under which prisoners live in the jails. In too many cases the jails are horribly insanitary and are managed in the most medieval fashion.

AMUSEMENT PLACES.

It is doubtful whether young men should be encouraged in making an inspection of saloons. They should, however, become familiar with the scientific literature, and they could profitably spend some time in studying the effects of alcoholism in their own town.

Theatres and moving picture theatres need the most careful and critical inspection. If the opinions of even immature children were gathered by the theatre managers, many shows would be discontinued. After all, the vulgar is not enjoyed by the majority of young people.

### Churches and Schools.

It is unfortunate that the supposedly model places, the schools and churches, are often among the most unhygienic buildings in the town. It needs but little scrutiny to see many points in which these might be improved. With youth enlisted in the cause, it would be but a short time before conditions would be remedied.

### Hospitals.

The fear of the hospital which even today exists in the minds of many, would tend to be eliminated if all young people were taken on tours of inspection of the work and benefits of a well-organized hospital.

### Cemeteries.

With young people instructed in sanitary methods, the insanitary cemetery will probably be replaced by the crematory. At any rate, wells near cemeteries would not be used in the smaller cities.

### Vital Statistics.

A proper realization of the death rates and the relative susceptibility to certain diseases at different ages is of inestimable value in inducing young people to take proper precaution and insist on the enforcement of the health laws of their town.

Sanitary surveys have been made by the writer's classes in a city of 30,000 inhabitants and in a village of 5,000.

While the prospective teacher may benefit by a brief preliminary training in methods of conducting such a survey, the greatest benefit results from the awakening of children and parents to existing evil conditions which menace their lives.

---

## A SMALL TABLE OF VALUES OF THE BINOMIAL COEFFICIENT.

By C. H. Forsyth,

*Dartmouth College, Hanover, N. H.*

Binomial coefficients play such an important part in so many branches of mathematics, such as binomial expansions, combinations, finite differences, etc., that it seemed worth while to offer a small table of values of the coefficient for reference, together with an explanation of a single method of setting them up, based solely upon continued or cumulative addition.

Although the table is small—a larger table would necessitate too much space—it will probably meet the vast majority of

everyday needs, while the suggested method of constructing the table will enable anyone to lengthen the table easily and quickly to meet particular needs.

As is well known, the expansion of $(a+x)^n$ may be written:

$$(a+x)^n = a^n + {}_nc_1 a^{n-1}x + {}_nc_2 a^{n-2}x^2 + \cdots + {}_nc_r a^{n-r}x^r + \cdots$$

where ${}_nc_r$ means the number of different combinations of $n$ things taken $r$ at a time. The table gives values of ${}_nc_r$ for all values of $n$ up to 20.

In order to simplify the construction of such a table, and finally to provide a check upon the work, two simple formulas are needed:

$$\text{Since } {}_nc_r = \frac{n(n-1)(n-2)\cdots(n-r+1)}{r!}$$

$${}_nc_r + {}_nc_{r+1} = \frac{n(n-1)(n-2)\cdots(n-r+1)}{r!} + \frac{n(n-1)(n-2)\cdots(n-r)}{(r+1)!}$$

$$= \frac{(n+1)n(n-1)\cdots(n-r+1)}{(r+1)!}$$

$$= {}_{n+1}c_{r+1} \qquad (1)$$

which means that if the values of ${}_nc_r$ are laid out in rows by $r$'s (as in the table), the sum of any two adjacent values gives the value just below the second. A glance at the table will render this fact clear and show that it may be applied to construct as large a table as is desired solely by continued or cumulative addition.

Since ${}_nc_r = {}_{r}c_{r} = 1$

by (1) ${}_{r}c_{r} + {}_{r}c_{r+1} (= {}_{r+1}c_{r+1}) = {}_{r+2}c_{r+1}$

Again, by (1)

${}_{r+2}c_{r} + {}_{r+2}c_{r+1} (= {}_{r}c_{r} + {}_{r+1}c_{r}) = {}_{r+3}c_{r+1}$

Continuing in this way, we have finally

$${}_{r}c_{r} + {}_{r+1}c_{r} + {}_{r+2}c_{r} + \cdots + {}_nc_r = {}_{n+1}c_{r+1} \qquad (2)$$

which means that the sum of the values, *except the last one, in* any column gives the last value in the next column to the right. Thus (2) can be used as a check upon the preceding work.

To those familiar with the finite calculus the following deriva-

tions of formulas (1) and (2) should prove interesting and seem more direct:

as ${}_nC_r$ may be written $n^{(r)}/r!$ where $n^{(r)} = n(n-1)(n-2)\cdots(n-r+1)$

then, with $n$ as the variable

$$\Delta {}_nC_{r+1} = {}_{n+1}C_{r+1} - {}_nC_{r+1} = \Delta\frac{n^{(r+1)}}{(r+1)!} = (r+1)\frac{n^{(r)}}{(r+1)!} = \frac{n^{(r)}}{r!} = {}_nC_r$$

which is formula (1).

Therefore, $\sum {}_nC_r = {}_nC_{r+1} + \text{constant of integration}$

and $\sum_{n=r}^{n=n} {}_nC_r = {}_{n+1}C_{r+1} - {}_rC_{r+1}(=0) = {}_{n+1}C_{r+1}$

which is formula (2)

When $r$ exceeds 9, the table should be entered with $r = n-r$, remembering that ${}_nC_r = {}_nC_{n-r}$

${}_nC_r$

| n | r=1 or n−1 | r=2 or n−2 | 3 or n−3 | 4 or n−4 | 5 or n−5 | 6 or n−6 | 7 or n−7 | 8 or n−8 | 9 or n−9 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | | | | | | | | |
| 2 | 2 | 1 | | | | | | | |
| 3 | 3 | 3 | 1 | | | | | | |
| 4 | 4 | 6 | 4 | 1 | | | | | |
| 5 | 5 | 10 | 10 | 5 | 1 | | | | |
| 6 | 6 | 15 | 20 | 15 | 6 | 1 | | | |
| 7 | 7 | 21 | 35 | 35 | 21 | 7 | 1 | | |
| 8 | 8 | 28 | 56 | 70 | 56 | 28 | 8 | 1 | |
| 9 | 9 | 36 | 84 | 126 | 126 | 84 | 36 | 9 | 1 |
| 10 | 10 | 45 | 120 | 210 | 252 | 210 | 120 | 45 | 10 |
| 11 | 11 | 55 | 165 | 330 | 462 | 462 | 330 | 165 | 55 |
| 12 | 12 | 66 | 220 | 495 | 792 | 924 | 792 | 495 | 220 |
| 13 | 13 | 78 | 286 | 715 | 1287 | 1716 | 1716 | 1287 | 715 |
| 14 | 14 | 91 | 364 | 1001 | 2002 | 3003 | 3432 | 3003 | 2002 |
| 15 | 15 | 105 | 455 | 1365 | 3003 | 5005 | 6435 | 6435 | 5005 |
| 16 | 16 | 120 | 560 | 1820 | 4368 | 8008 | 11440 | 12870 | 11440 |
| 17 | 17 | 136 | 680 | 2380 | 6188 | 12376 | 19448 | 24310 | 24310 |
| 18 | 18 | 153 | 816 | 3060 | 8568 | 18564 | 31824 | 43758 | 48620 |
| 19 | 19 | 171 | 969 | 3876 | 11628 | 27132 | 50388 | 75582 | 92378 |
| 20 | 20 | 190 | 1140 | 4845 | 15504 | 38760 | 77520 | 125970 | 167960 |

## RESEARCH IN CHEMISTRY.

**Conducted by B. S. Hopkins.**

*University of Illinois, Urbana.*

*It will be the object of this department to present each month the very latest results of investigations in the pedagogy of chemistry, to bring to the teacher those new and progressive ideas which will enable him to keep abreast of the times. Suggestions and contributions should be sent to Dr. B. S. Hopkins, University of Illinois, Urbana, Ill.*

---

## TUNGSTEN, TANTALUM, COLUMBIUM.

By GEORGE W. SEARS,

*Assistant Professor of Chemistry, University of Nevada.*

The chief characteristics in the history of many of the rarer metals may be summed up in the three phrases, a chemical curiosity, investigation from a purely scientific standpoint, the discovery of useful and valuable properties followed by a rapid development. Tungsten, tantalum, and columbium give us a picture, as it were, of this history. Less than twenty years ago tungsten was practically unknown, but a careful study of its properties soon led to its employment in the steel industry and later in the manufacture of filaments for incandescent electric lamps, so that now it is almost a household word. Tantalum is just coming into prominence as a useful metal, and tantalum dental and surgical instruments are eagerly sought by those who have learned their value. Columbium is yet but little more than a chemical curiosity with practically no commercial application.

Situated as they are in the fifth and sixth groups of the periodic table, these three elements show a relation in their physical properties and chemical activity which might well lead one to expect that both tantalum and columbium will attain the wide range of usefulness which already has been reached by the more fully developed tungsten. In appearance, specific gravity, and melting point they are not widely different. Pure tungsten and tantalum are characterized by their ductility, toughness, and malleability, while in the less pure condition both are extremely hard and brittle. In columbium these properties are somewhat less marked. In the cold all three are very inert but rapidly oxidize on heating to redness. With the exception of hydrofluoric acid tantalum and columbium are unattacked by all acids or mixtures of acids. Tungsten is slowly dissolved in hot concentrated sulphuric or hydrochloric acid. All are stable toward solutions of caustic alkali but are attacked by molten alkali nitrates, sulphur, and fused caustic alkali.

The chief ores of tungsten are wolframite, scheelite, hubnerite, and ferberite. Although ores containing tungsten have been known for a long time it was not until 1781 that Scheele discovered in scheelite a peculiar acid which he named tungstic acid. A little later the same acid was shown to exist in wolframite. While tungsten ores occur in a number of localities in both Europe and America, the United States is by far the largest producer. In 1916 the output in the United States amounted to 3,200 tons valued at $9,400,000. Large deposits of ferberite and scheelite are found in Boulder County, Colorado, from which a large part of the United States production has been taken. Considerable amounts of hubnerite, wolframite, and scheelite are being mined in Nevada and California.

Owing to the high specific gravity of tungsten ores, their concentration by various mechanical settling processes is relatively simple. However, certain European ores contain large amounts of cassiterite from which it is very difficult to separate the tungsten by these processes. It has been found advantageous in these cases to make use of magnetic separators. The tungsten ore usually contains enough iron to give it magnetic properties. The further treatment of the concentrate varies somewhat with the nature of the ore. A method which has been used quite extensively with wolframite consists in fusing the concentrated ore in a reverberatory furnace with a mixture of $Na_2CO_3$ and $NaNO_3$. This produces a soluble sodium tungstate which is lixiviated with water, filtered from insoluble matter and the tungstic acid precipitated with hydrochloric acid. The method has not been wholly satisfactory owing to the large quantities of reagents necessary and the consequent loss due to the slight solubility of the precipitates. Scheelite may be decomposed with concentrated hydrochloric or nitric acids with the formation of a soluble calcium salt and insoluble tungstic acid.

For the production of pure tungsten, ammonium tungstate is precipitated from a solution of alkali tungstate with a current of ammonia gas. This is purified by further recrystallization and finally precipitated as $WO_3$ with nitric acid. The oxide obtained in this manner is dried, ignited, and reduced in a current of hydrogen at a temperature of 1000° to 1200°. A pure tungsten cannot be obtained by reduction with carbon, owing to the formation of tungsten carbide ($W_2C$).

By far the largest part of tungsten produced is used in the

manufacture of steel. This finds a ready market for high speed tools, armor plate, projectiles, and firearms. Perhaps the most important property which it imparts to steel is extreme hardness and toughness. It is added in proportions varying from 2 to 12 per cent of the steel. Either alone or as an alloy with molybdenum it is finding increasing use as a substitute for platinum in the manufacture of contact points for electric welding, spark coils, signal relays, sending keys, etc. Owing to its greater conductivity and higher melting point it remains much cooler during operation and lasts longer than the platinum. Alloyed with thorium it is used as a refractory material.

Compounds of tungsten also find considerable use. Sodium tungstate is used in fireproofing curtains and draperies. Calcium tungstate on account of its fluorescence is used as a screen to make X-rays visible. Other compounds are used in glass and porcelain coloring, in making certain bronze powders, and in weighting silks. The amount of tungsten used for these purposes, however, is still relatively very small. The total consumption of tungsten in 1915 for purposes other than steel was about five tons, or less than 1 per cent of the tungsten produced.

Tantalum and columbium occur in a large number of ores and almost invariably occur together. Only a very few of these ores, however, are as yet of commercial importance. Tantalite containing from 40 to 70 per cent $Ta_2O_5$ is the chief source of tantalum. In most specimens of tantalite[1] some of the iron is replaced by manganese and some of the tantalum by columbium. Columbite is similar to tantalite in composition except that it contains a larger proportion of columbium. Although small amounts of tantalite are mined in Connecticut and in the Black Hills, the large majority of the tantalum so far used is obtained from Western Australia, where a high grade tantalite is found. As a rule the Australian tantalite contains 50 to 70 per cent $Ta_2O_5$ while that found in America seldom has more than 40 per cent.

Owing to the great similarity in the chemical nature of tantalum and columbium and the insolubility of their salts in the common acids, their separation and reduction are comparatively difficult and tedious operations. The metallurgy consists of two distinct procedures, first the preparation of a pure salt, and second its reduction to the metal. According to the method of Marignac (1866), the finely powdered ore is fused

[1]The general formula of tantalite is given in the table at the end.

with three times its weight of $KHSO_4$. The fused mass is cooled and lixiviated with water. Tantalum and columbium along with small amounts of tin, tungsten, iron, and silica are left undissolved. This residue is digested with $(NH_4)_2S$ to remove tin and tungsten, then treated with hydrochloric acid to dissolve the iron. After a thorough washing the remaining tantalum, columbium, and silica are dissolved in hydrofluoric acid. By this treatment the silica is volatilized as $SiF_4$. To the solution containing only tantalum and columbium fluorides KF or $KHF_2$ is added when most of the tantalum precipitates as $K_2TaF_7$ and most of the columbium is left in solution as $K_2CbOF_5$.

A more satisfactory method, however, than that of Marignac consists in fusing the ore with potassium hydroxide. This renders the tantalum and columbium soluble in water while most of the impurities remain in the residue. The solution containing the tantalate and columbate of potassium is acidified with hydrofluoric acid which precipitates most of the tantalum as in the method of Marignac.

Tantalite and columbite may be decomposed directly with hydrofluoric acid and the $K_2TaF_7$ precipitated from the resulting solution by the addition of KF or $KHF_2$. This method, however, is not very satisfactory since iron and manganese form double fluorides isomorphous with $K_2TaF_7$, thus rendering their separation much more difficult.

The $K_2TaF_7$ obtained by any of the above methods is further purified by recrystallization from water made slightly acid with hydrofluoric acid. In order to obtain the salt in the purest condition three to four crystallizations have been found necessary.

The reduction to metallic tantalum may be accomplished in a number of different ways. One of the oldest methods, proposed by Berzelius and Rose, consists in placing the $K_2TaF_7$ in a crucible with layers of metallic sodium and starting the reaction by the application of heat. When the reaction is complete and the mass is cool it is treated first with water and then with nitric acid. The metallic tantalum is left in a more or less impure condition.

In 1903 von Bolton patented an electrolytic process in which the fused $K_2TaF_7$ is electrolyzed, giving a somewhat impure metallic powder. This is further purified by melting in vacuo between tantalum electrodes. By this means the impurities which are more volatile than tantalum are vaporized. The

Thompson-Houston Co. of England obtained a patent in 1906 whereby they electrolyze the fused $K_2TaF_7$ in a refractory crucible of magnesia or tantalic oxide, using a cathode of pure tantalum and an anode of impure tantalum. In 1907 a French patent was obtained which provided for the electrolysis of a solution prepared as follows: A solution of potassium tantalate is precipitated with sulphuric acid, filtered, washed with water, and redissolved in oxalic acid. The solution obtained in this way is neutralized with ammonia, and sulphuric acid is added to make a three per cent solution. This is electrolyzed between platinum or carbon electrodes, using 2 volts and .1 to .3 amperes. This process is said to give very pure tantalum.

Carbon cannot be used for the reduction of tantalum compounds, owing to the formation of tantalum carbide.

It has already been mentioned that tantalum is only in the beginning of its usefulness. Its employment in the manufacture of electric light filaments was just coming into prominence when the advent of the more efficient tungsten filaments drove it completely off the market. The comparative efficiency of the various filaments is shown in the following table:

| *Kind of Filament.* | *Watts Required per Candle Power.* |
|---|---|
| Carbon | 3.00 |
| Metallized carbon | 2.50 |
| Tantalum | 1.70 |
| Squirted tungsten | 1.25 |
| Drawn tungsten | 1.00 |
| Nitrogen filled tungsten | .50 |

The dental and surgical instruments made of tantalum possess many advantages in that they are nonrusting and may be sterilized in acids or at a moderate red heat. They can be sharpened the same as steel. For dental purposes the instruments are surface hardened by secret processes so that they are about as hard as agate. Tantalum pens, employed quite extensively in Germany, possess great elasticity and hardness, do not rust, and are not corroded by the ink. Tantalum may be used to replace platinum as cathode in all places. When used as anode, however, it becomes coated with a poorly conducting oxide, $Ta_2O_4$. Many metals as silver, copper, zinc, nickel, platinum, and antimony have been quantitatively deposited on tantalum cathodes. Tantalum cathodes possess the added value that the deposited metal may be dissolved off with acids or even aqua regia. It has been suggested that tantalum weights would be equally good if not superior to those of platinum. Laboratory fumes

would have no corroding effect. Tantalum has found only a limited use in the manufacture of steel.

From a commercial standpoint the compounds of tantalum are of little importance except as a means of its separation and purification. The oxide, $Ta_2O_5$, has a limited use as a refractory material. It has already been said that $K_2TaF_7$ is the compound usually prepared for the separation and purification of tantalum, it is therefore the starting point for the preparation of other compounds of tantalum.

Up to the present time the chief interest in columbium has been that of the purely scientific investigator. The fact, however, that a U. S. patent taken out only last year (1916), providing for .1 to 10 per cent of columbium to be mixed with tungsten for making incandescent electric light filaments, is an indication that useful properties are being discovered and that uses will be found.

For the separation of columbium and its purification the $K_2CbOF_5$ solution obtained in the precipitation of tantalum as $K_2TaF_7$ is evaporated to dryness and ignited at a low temperature for several hours to render the tantalum insoluble. This ignited residue is moistened with strong hydrofluoric acid, then taken up in water and the whole process repeated until no further test for tantalum is obtained. The pure columbium salt is decomposed by heating strongly with sulphuric acid, cooled, and the resulting columbic acid washed with large volumes of water to free it from $K_2SO_4$. On ignition $Cb_2O_5$ is obtained. If this is mixed with paraffin and drawn into fibers it may be reduced to $Cb_2O_4$ with carbon. The tetroxide formed in this way is a conductor and may be reduced to metal by heating highly in vacuo. The metal may be obtained also from the pentoxide by means of Goldschmidt's process or by reduction with "mischmetal." By passing $CbCl_5$ vapors mixed with hydrogen through a red-hot tube the columbium is reduced. It may be obtained by the electrolysis of $K_2CbOF_5$, using methods similar to those for the preparation of tantalum.

The compounds of columbium are in general similar to those of tantalum and possess very much the same properties. A few differences, however, may be noted. $K_2TaF_7$ crystallizes in long needles belonging to the orthorhombic system and is soluble in 150 parts of water, while the corresponding columbium compound, $K_2CbOF_5$, crystallizes in hexagonal plates and dissolves in 12 to 13 parts of water. Advantage is taken of this differ-

ence in the separation and detection of the two elements. The shape of the crystals is the most delicate and reliable test for either tantalum or columbium. Freshly precipitated columbic acid when treated with zinc and hydrochloric or sulphuric acid forms reduction compounds with hydrogen peroxide, potassium thiocyanate, potassium ferrocyanide, tannin, and pyrogallic acid as well as with a number of other compounds. In each case the resulting compound is colored. Tantalic acid is not reduced under similar conditions.

The following table gives a comparative view of the three elements.

| Element. | Tungsten. | Tantalum. | Columbium. |
|---|---|---|---|
| Principal ores | Wolframite $(Fe, Mn)WO_4$<br>Scheelite $(CaWO_4)$<br>Hubnerite $(MnWO_4)$<br>Ferberite $(FeWO_4)$ | Tantalite $(FeTa_2O_6)$<br>Microlite $(Ca_2Ta_2O_7)$<br>Fergusonite $(Y, Er, Ce)(Ta, Cb)_2O_4$ | Columbite $(Fe, Mn)(Cb, Ta)_2O_4$<br>Samarskite $III\ II\ R_2R_2(Co, Ta)_6O_21$ |
| Color | Gray to brownish black | Dark gray | Steel gray, brilliant luster |
| Hardness | Cast metal very hard, pure metal much softer | Equal to ordinary steel | Equal to wrought iron |
| Specific gravity | 18.8 | 16.8 | 12.7 |
| Melting point | 3080°C. | 2910°C. | 1950°C. |
| Effect of heat | Burns slowly to oxide. Powder burns very readily. | Burns slowly to oxide. Powder burns very readily. | Burns slowly to oxide. Powder burns very readily |
| Action toward acids | Attacked by hot HCl, $H_2SO_4$, or mixture of $HNO_3$ and $H_2F_2$ | Attacked by $H_2F_2$ only. | Attacked by $H_2F_2$ only. |
| Action toward alkalies | Attacked by fused alkalies, alkali nitrates, carbonates, and disulphates. | Attacked by fused alkalies and alkali nitrates. | Attacked by fused alkalies and alkali nitrates. |

## THE BONDS ON STOCK EXCHANGE.

The daily quotations of Liberty Loan bonds on the New York Stock Exchange below par do not represent any real loss for those holders of Liberty Loan bonds who do not need to sell them. The figures do mean a very small loss for those who find themselves compelled for one reason or another to sell; but those who hold on to their bonds have one of the very best investments in the world—absolutely safe, free to a great extent from taxation, and bringing in an absolutely certain income. The loss to them is purely imaginary, a paper loss, not a real one.

Secretary McAdoo, in a speech before the Liberty Loan conference in Washington, December 10, made the statement that, while sufficient legally competent evidence was not in hand to warrant conviction before a jury, yet enough was known morally to convince a man of understanding that the hand of the Kaiser was at work in bringing about sales of Liberty Loan bonds and depressing their price on the exchange. This is added proof that the loss indicated by the difference between par and the stock exchange prices is fictitious and not real.

## RESEARCH IN BIOLOGY.

**Conducted by Homer C. Simpson.**
*Ohio State University, Columbus.*

*It is the object of this department to present to teachers of physics the results of recent research. In so far as is possible, the articles and items will be nontechnical, and it is hoped that they will furnish material that will be of value in the classroom. Suggestions and contributions should be sent to Dr. Homer C. Simpson, Department of Zoology, Ohio State University, Columbus, Ohio.*

## A REVIEW OF SOME RECENT ATTEMPTS TO INFLUENCE THE GERM PLASMS OF ANIMALS.

By W. M. Barrows.
*State University of Ohio, Columbus.*

The value of zoology aside from its practical applications in animal breeding, in the elimination of pests, et cetera, extends much deeper and has a more definite philosophical significance than we are accustomed to recognize. Many of the practical problems of everyday life are settled by what we know, or think we know, about the activities of our own bodies or about those of familiar animals. Our whole view-point in life is very largely determined by what we know about the factors which are to improve or damage the generations which are to follow us. The high school student who is told that men are the products of their environment will have an entirely different outlook from one who is told that "blood will tell" and that the environment has little effect on what a man is or what his descendants will be. Let us cite two specific cases. We have been taught that a drunkard is the result of his environment alone or the environment of his ancestors, that alcoholism causes the development of alcoholics. Very few teachers have the courage to point out that a weak nervous system which is inherited may lead to alcoholism and that the son may be like the father (alcoholic), not because of the environment but because of the inherited lack of something in his nervous make-up which allows him or even leads him to become a drunkard or to go to other excesses. Again, the whole question of blind fish in caves may be stated in two ways—first, are fish in caves blind because of the action of the darkness of the caves on their germ plasms or on each embryo as it develops, or, second, are they in the caves because in going blind regardless of the light they could survive only in such places as caves, where competition is less severe and eyes so necessary?

It is not the intention to take these matters up here. They

have been discussed from several points of view by Eigenmann, Davenport, Jennings, Conklin, and others. References to these articles may be found in the bibliography at the end of this article. Obviously, any experimental work which demonstrates the effects or lack of effects of the environment on the germ plasm of animals will have a direct bearing on this subject. It is with this idea in mind that the following material is reviewed.

It is quite obvious that the developing chick in the egg is not much influenced by the activities of the mother hen except as regards temperature, moisture, and mechanical disturbances of the egg. In other words, a good incubator will hatch out the same kind of chicks and will hatch them about as well as their own mother. We must not forget, however, that the egg cells (yolks) as they develop in the ovary may be influenced by the body of the female parent before they are laid or the sperm cells in the male may be influenced. Among the mammals, the developing young are separated from the female parent but not so completely as are the chicks in the egg. Three questions arise in our mind immediately. Are the eggs and developing young more influenced by the parent or less than those of the bird? Do external factors influence the germ cells before fertilization? If so, do the same stimuli affect different animals in different ways? While recent researches have not given by any means a complete answer to these questions, some progress has been made and many interesting experiments have been recorded.

In 1897 Heape showed that when the fertilized egg of a rabbit of one variety (for example, a long-haired albino) was removed from the oviduct of the mother before it had become attached to the uterine wall, and was transferred to the oviduct of a rabbit of a different variety (for example, a Belgian hare which is neither white nor long-haired), the transferred egg became attached in its new position and passed through all the stages of gestation. Young rabbits produced in this way were both long-haired and albinos like the mother of the eggs, not like the rabbit which bore the young (Castle and Phillips). This experiment shows very clearly that the body of the parent has little if any effect on the developing young. It does not indicate, however, that the eggs may not be influenced by a foster mother if they *grow up* and mature in the body of the foster mother. This case may be tested by transplanting the ovary from one individual to another and allowing the egg to go through the stages of

development previous to fertilization within the foster mother.

Castle and Phillips have made many ovary transplantations from one young female guinea pig to another. These foster mothers were then mated to males whose color and ancestry were known. In three cases the foster mothers raised young. In one case an ovary from a black female had been placed in a white guinea pig which was then mated to a white male. White offspring would be expected because white by white always produces white. However, the six young were all black. The eggs from the black female had not been influenced so far as could be detected. These and other experiments make it seem unlikely that the body cells or normal bodily processes leave any effects on the germ cells.

Eggs developing in the ovary or sperm cells developing in the testis if not influenced by the parents' make-up are not likely to be influenced by the ordinary changes in the environment from which they are protected by the body of the parent. Some changes of the environment, however, do penetrate the tissues of the ovary or testis and may cause changes directly in the germ cells.

Two interesting series of experiments in which alcohol vapor was administered to fowls and guinea pigs did not yield exactly similar results. According to Stockard, offspring from guinea pigs, which had been made to inhale alcohol for long periods before mating, were much less vigorous and showed among them many more abnormal young than the untreated stock. These abnormal young appeared during the three or four generations subsequent to the treatment, the individuals showing abnormal nervous systems, sense organs (especially the eyes), and in a few cases abnormal legs. Analysis of his results indicates that sperm cells are more easily affected by alcohol than egg cells, and it seems likely also that the sons of alcoholized mothers are more affected than the daughters, while the daughters of alcoholized fathers are more injured than the sons. The per cent of deformed offspring from inbred descendants of alcoholized stock sometimes ran as high as fifteen per cent, while the descendants of normal stock showed no deformities.

If we assume that alcohol has the same effect on man and guinea pigs we would have data to delight the most ardent prohibitionist, but before making the comparison it may be well to note two more researches. In a long and carefully executed experiment with fowls which were made to inhale

alcohol, methyl alcohol, or ether, Pearl has found that from birds, one or both of which had been treated, fewer fertile eggs were obtained, but of these eggs which were fertile fewer died during development than in the untreated stock. The offspring of treated parents showed a higher average body weight than the offspring of the untreated. They were a selected, superior set of offspring, the weaker eggs and sperms having been eliminated by the treatment. The treated and untreated animals produced about the same proportion of abnormal chicks (treated, 1 to 234, untreated 16 to 1,527). This indicates that surviving eggs and sperms were not injured so far as could be detected, though it is possible that a more severe treatment would have produced some injury. Guinea pigs are apparently much more likely to be injured by alcohol than fowls.

Elderton and Pearson, who made a careful statistical study of alcoholic parents and children, found that "the general health of the children of alcoholic parents appears on the whole slightly better than the health of the children of sober parents. There are fewer delicate children, and in a most marked way cases of tuberculosis and epilepsy are less frequent than among the children of sober parents. The source of this relation may be sought in two directions. The physically strongest in the community have probably the greatest capacity and taste for alcohol. Further, the higher death rate of the children of alcoholic parents probably leaves the fitter to survive" (p. 31). "To sum up then, no marked relation has been found between the intelligence, physique, or disease of the offspring and parental alcoholism in any of the categories investigated. On the whole the balance turns as often in favor of the alcoholic as of the non-alcoholic parentage" (p. 32).

Cole and Bachuber have found that acetate of lead taken internally seriously affects the sperm cells of the male rabbit, causing the offspring to be weak and underweight, and causing a considerable mortality shortly after birth. In these experiments the litters were in all cases from one mother and two fathers, one of which was poisoned. The colors of the males differed so that the male parent of each young rabbit could be determined at birth. The effect of the lead on the germ cells of the males could be estimated by comparing the young and the relative number of young from each male.

Other agents which have been used with success are the light waves of very short wave length, ultra violet rays, X-rays, and

radium rays. Guyénot and also Packard have experimented with these, using the fruit fly (Drosophila). The germ cells are much more easily affected than the body cells, though in this case the germ cells seem to be either not affected at all or eliminated completely. Hereditary modifications do not seem to be caused.

The limits of a paper of this nature prevent us from reviewing the extensive literature of this subject. Part of the literature is speculative, part needs repeating or verification in some particular. For our purposes we may make certain statements in conclusion which will serve to summarize the prevailing opinions held by zoologists at the present time as to the status of this very fundamental question. First, it may be stated that no clear-cut proof exists that the bodies of animals normally have any directive or modifying influence on the germ cells or embryos which they contain. Weismann's contentions have been supported, and Lamarck's have been discarded. Second, certain external readily transmitted materials or forces do act directly on the germ cells, eliminating or injuring them in some cases. Inherited injury in this case is not usually comparable to the process known as mutation or the production of new hereditary variations, but rather to a general weakening effect. Third, it is not safe to assume that because one agent causes a certain change in the germ plasm of one animal that it will cause a similar change in another animal.

### Bibliography.

Castle and Phillips: *Carnegie Inst. Publication No. 144* and *Science*, Nov. 28, 1913.
Cole and Bachuber: *Proc, Soc. Exp. Biology and Medicine*, Vol. XII, No. 1, Oct. 7, 1914.
Conklin: *Science*, Jan. 10, 1913, pp. 46-54.
Davenport: *Pop. Sci. Mon.*, July, 1913, Vol. 83, p. 33.
Eigenmann: *The Geographical Review*, Vol. IV, No. 3, September, 1917, p. 171.
Elderton and Pearson: *Eugenic Lab. Memoirs X* (London), p. 1.
Guyenot: *Bull. Scientifique, 7e* ser., 7, XLVIII.
Heape: *Proc. Roy. Soc.*, V. 48, p. 457, and V. 62, p. 178.
Jennings: *Science*, Dec. 29, 1911, p. 902.
Packard: *Jour. Exper. Zool.*, Vol. 19, No. 3, October, 1915, p. 332.
Pearl: *Jour. Exper. Zool.*, Vol. 22, No. 1, p. 125, and No. 2, p. 241.
Stockard: *American Naturalist*, Vol. 50, p. 65, and p. 144.

## THE FABRIC OF OUR PHYSICAL KNOWLEDGE.

By ROGERS D. RUSK,
*Columbus, Ohio.*

The teacher of physics in the secondary school is frequently so engrossed with a study of the details of physical phenomena that he overlooks the larger meaning of the science, its actual basis in thought and reality, and the fundamental relations of its parts. Certainly a comprehensive view of any science as a whole is as valuable and as important to the teacher as a more intimate acquaintance with its details. Such a view should make the study mean vastly more to the teacher himself, and enable him to present his subject with much more of that degree of understanding to be desired and yet so often found lacking.

Sooner or later both student and teacher of any science must look at the facts of that science as a whole, and ask themselves the question, "What is the actual basis in reality of this intricate construct called a science?" The man of the street says a thing *is*, or *is not*, so *absolutely* because science has proved or disproved it. In this he discloses a naive ignorance as to the significance of science and the meaning of proof, to say nothing of his utter neglect of the fact that scientific knowledge is a mental fabric more or less conditioned by the mind itself. We cannot escape the fact that science is not final, that it is far from it, in fact, and that man's true knowledge of the external world as such can be obtained through no more than five gateways to the mind—the five senses. If the real basis of a science is thus in doubt, its superstructure can be no more substantial. Certainly, the physicist should analyze the situation as fully as possible. He should understand his position as a physicist, and if the principles of psychology and philosophy can be of aid to him he should use them. Too often these subjects suggest infinite terrors to the teacher of physics instead of aiding him very greatly in the fuller criticism of his own position as they really should. If psychology and possibly philosophy are invoked rather freely in the following pages, it is only because of their fundamental connection with physics, which too often passes unnoticed.

Man's sum total of knowledge does not consist of what he *knows* to be absolutely and unqualifiedly true with reference to external reality, but rather it is composed of those mental constructs which are too often taken to be a *complete* representation of external reality.

It *should* be well known that knowledge of the external world is obtained in only two ways; directly through one's own personal experience or indirectly by accepting the personal experience of others as being as valid as one's own. It is true that man has added much more of a hypothetical nature to these sense data, but this is based upon man's analysis and interpretation of his sense data. The additions exist as realities for us in thought alone. They do not represent perceptual realities, and hence are purely conceptual. A block of wood may exist as an object of perception but the atoms composing it are conceptual. Our body of knowledge is therefore a complex quantity. It is not always easy to separate percept and concept in thought, but in looking at the fabric of scientific knowledge from a critical viewpoint, it is *necessary* to distinguish between the purely perceptual and the purely conceptual (that which exists as a sense-stimulating reality and that which exists in thought alone), in order to have a basis for analysis. The words *real* and *ideal* may serve to distinguish these states, keeping in mind that *real* is used not in the sense of meaning absolutely existent, but in the sense of meaning perceptually possible, while *ideal* refers to that which is not perceptually possible. Both realities and idealities are, to say the least, mind products and conditioned by the mind. Their relation to absolute existence is one thing, and their relation to each other is another entirely different, but obviously more real so far as man is concerned.

Of such materials is science built, and the superstructure of generalization, theory, and hypothesis must be built firmly upon the foundation of actual human experience. This implies that the divisions of physics cannot be haphazard affairs, and their relations to each other cannot be based upon mere superficialities. They must be grounded firmly on the fundamental elements of human experience. Certainly the activities of those who are at present crying loudly for unity of material in the sciences should be conditioned by such facts.

If we are going to evaluate our science in terms of knowledge itself let us look a few moments at some of the general facts concerning knowledge. An apple from my desk is an object of perception, for I know it by sight, taste, and touch. India I recognize as a far distant land because I accept the experience of other beings as I would my own; but an atom and the ether, not being objects of perception by myself or anyone else, are distinctly conceptual in character. The question, "Do I know

the atom or ether exists?" leads directly to the question, "Do you really know the apple exists, and that India *is* a distant land?" We need not bother with the argument of the idealists versus the realists, and the disagreements of the metaphysicians concerning reality, but we will *accept* a real existence for the objects of our perception and a very close connection between our own mental activities and this ultimate reality. What that connection is, is a question for the metaphysician; the scientist cares only for its conditions.

When I see an apple I have a certain mental image separated in space and time from other mental images. I put out my hand, and my brain speaks up in consciousness through another sense, and says, "Sir, you have touched something smooth and round." My brain might go on noting details, but it has done that before, and so for convenience it winks at me and says, "That is an apple," and you agree of course. What you actually *know* is that you have had certain sense experiences. You *know* nothing of the real existence of the apple. The brain may tell you in five different ways a thing exists, but that does not make it exist. The brain tells a color-blind man that red is green, but that does not make it green. It only makes him know that he sees green.

It is conceivable that a demon such as suggested by Maxwell with power of super-sight would see an apple as a beautiful geometric dance of electrons; while a being with a super-moral sense might see it as an object of moral significance on a plane with the Bible. (It is entirely conceivable that the universal laws of which the apple is in some way an expression, might be so perceived.) What is it then, that to one being appears an apple, to another appears a moral principle, and to another appears a dance of electrons? Evidently it depends upon the *being*, and we are up against the blank wall of ultimate reality again. We do not know what it is ultimately, but we do know that to us it is an apple, red, ripe, mellow, of pleasing flavor, good for food, and we know further that it is the same to each and every normal mind. So much for the apple. Our knowledge of India is one step further removed, and the electron and ether of the physicist seem hazy apparitions indeed.

To the physicist, however, who cares little or nothing concerning ultimate reality, and who cares everything about the sequences and relations of phenomena, the electron is a certainty and the ether an everyday tool of thought. This is because

*science* is based upon nothing extra-mental, but upon the five little speeches made by the senses to the brain concerning the objects of perception; and the fact that we have interpreted the data so gathered in just the best possible manner to allow of still further useful and sound interpretation. It is the duty of the physicist to not only realize the physical limitations of his science, but also to realize why he is justified in considering the ether, the electron, and many other conceptions as real enough to use as working tools.

It is difficult for us as we leap through our physics text to look at the mass of material before us in the light of its true value, for it is difficult to definitely separate concepts and percepts, and difficult to keep in mind that the basis of the system lies in sense experience. The first section we note is usually devoted to mechanics. The teacher often naively suggests that this is of extreme importance; but that is a somewhat barren statement. The fact is that this section contains the major part of the direct data of the senses. Here has been put down what we know about matter at rest and in motion, judged by the categories of time and space. Here we see familiar paragraphs on statics, translatory and rotary motion, hydrostatics and hydraulics, and wave and oscillatory motion. Under these heads we have classified our data, analyzed them, and made them the basis for just inferences. The whole structure we have called mechanics for short, and upon this, nearly the whole of what follows is based.

Our senses of sight and hearing and a special quality of touch have acquainted us directly with the phenomena of light, sound, and heat, and thereupon we have established the other common divisions of the ordinary text, but these qualities of sense did little to explain or fully describe what was going on. In reality we always referred these phenomena back to mechanics for a more complete description and one we could more readily grasp and understand. We realize today that it is ridiculous to consider these as natural divisions inherent in the order of things, but that it was our lack of knowledge and our limited perceptive ability which caused us to so order our data; in other words, it was the human element again. However, the body of knowledge thus obtained has enabled us to transcend the powers of sense, and discover electricity, wireless telegraphy, X-rays and radioactivity.

When the magnetic needle moved toward the north, the turn

of a switch started a motor, and the press of a key sent an invisible signal across the ocean, we were compelled to add the extra divisions, magnetism, electricity, and radiation, to the body of our growing science. The phenomena thus included did not follow the known laws of the commoner divisions of physics, and we had to invent explanations. In mechanics we had to invent very little; the subject was almost purely descriptive. In heat, light, and sound, we had to fill in many perceptual gaps with mechanical concepts, to enable us to go forward, but when it came to electricity, and magnetism, besides building on the concepts of mechanics, heat, light, and sound, we still had a multitude of gaps to fill with conceptual figments. Science is today still busy filling these gaps to the best of her ability with theories and hypotheses which will not only harmonize with perceptual facts but which will form the basis for future reliable inferences. It is only possible to do this through the shortened methods of symbolism better known as mathematics. It is the physicist's dependence upon mathematics which has given the mathematician a chance to playfully affirm that physics is only an offshoot of mathematics. Certainly, the relation between the two subjects grows closer as both proggress. The answer to the affirmation, which no matter how playfully made contains an undoubted truth, lies in the fact that mathematics is no other than richly developed symbolic logic, and physics to be rational must put itself completely in the hands of logic. So it is that we use our mathematics to enable us to organize to the highest point our data, and to enable us to use this organization to do the most reasonable and useful things possible. Hence our system is rational per se, and if the conceptual facts demand the existence of the electron, and if experiment proves the validity of such conclusions so far as perceptually possible, and if such a concept enables us to make progress and discoveries otherwise impossible, then the scientist assumes its real existence, no matter what the metaphysician has to say. All the scientist has to do is to keep his mind open and remember that an altogether sound framework cannot well be built upon a foundation which is not itself ultimate, and that he has done the best he can. How shaky is the framework then, and how fictitious are our concepts?

When I push a block of wood it moves. When the magnet moves a needle I make a mental compromise and say *something* pushed or pulled it. When I see a certain color I believe it to

result from matter or motion. I gain a little perceptual evidence, and say it must be a motion; I gain a little more perceptual evidence, and I say it is not like a longitudinal wave in a spring, it must be something transverse like a water wave, and by rapid methods of reasoning, using the various mental economics of mathematics, I say it must be a certain form of that with which I am otherwise familiar, and if this is true, other things are true because they have been true at other times. Being a wave it must be a wave of something. Now if we assume a *something* and call it the ether, it must work according to the fact of our real knowledge, else we need not assume it. The only reason we assume it in the first place is in order to permit us to have a tool to think with, and one that will enable us to think in the right direction. J. Clark Maxwell gave us our ether of today. Previously, ethers had been suggested, but with too hard and fast material properties to make them applicable to all conditions. That was Maxwell's accomplishment, to give us a mathematical concept that covered the perfectly general case, upon which rapid development could be made. Maxwell's ether is a *reality*, that is, it is a concept which has proved its own value, and its own application to physical problems. It is not a reality in the sense in which the term was introduced in this article. It is not perceptually possible, and the modern followers of the action-at-a-distance theory would have us believe there is no ether at all. However that may be, Maxwell never intended to answer such universal riddles as to what is ether, matter, electricity, etc.? He only attempted and succeeded in showing us how electricity and matter interact, and that such interactions occur just as if there was an intervening ether which obeyed simple mechanical laws. It was an epochal achievement, and Maxwell's fame will never grow dim. The outline growth of this concept is typical of all. Sometimes a conceptual body approaches closely the border line dividing concept and percept, as the electron has done through brilliant experiments such as Millikan's. But no matter how near it comes it is still a long way off, and other concepts as that of the ether seem no nearer a perceptual justification now than a thousand years ago. It is as if the scientist had climbed to his present height upon a pile of boxes. He cannot quite justify his position, because he made the boxes himself, and he cannot kick out any beneath him for they have put him where he is and the structure would then collapse. The results alone justify the position and the necessary, inseparable connection of all the elements of the structure is apparent.

Such considerations do not discount the value of physics but rather do exactly the opposite, for they enable one to see better just what the science is that he is working with, and just wherein its true value lies. Though the basis of physics exists in sense perception, man has been able through his intellectual power to transcend the limits of the senses. Our knowledge of physical laws and phenomena greatly surpasses perceptual possibility. And though physics as a science does not pretend to be ultimate, it seems at least that through it we are approaching a realization and appreciation of the ultimate universe, and its ultimate laws.

---

## A PLATINUM "FAKE" IN OREGON.

The present shortage of platinum and the consequent greatly increased price of the metal bid fair to result in a considerable increase in the domestic production of platinum during the coming year. At the same time, while legitimate miners are increasing their production and to some extent relieving the country's shortage, other persons are using the interest aroused by the present nation-wide search for the metal to make extravagant claims for utterly worthless deposits, and some honest prospectors are led by false assays, made by inefficient or venal assayers, to believe mistakenly that they have valuable platinum deposits. Reports of platinum in some mythical combination—"volatile platinum" or "colloidal platinum"—should be regarded as sufficient evidence of the incompetence or dishonesty of the assayer.

During the season of 1917 the geologists of the United States Geological Survey, Department of the Interior, spent much time in visiting platinum deposits that proved to be worthless. A notable example is seen in the supposed platiniferous sands of the Deschutes River, near Terrebone, Ore., which were examined by H. G. Ferguson in October, 1917. Claims have been staked for several miles along Deschutes and Crooked Rivers, and as certain volcanic sands along these rivers had been said to contain large percentages of gold and rare metals, particularly metals of the platinum group, Mr. Ferguson visited the localities at which the sands were obtained and took samples for test and analysis.

The material collected, which is exposed in the canyon of the Deschutes River north of Low Bridge in Sec. 15, T. 14 S., R. 12 E., consists of loosely cemented dark volcanic sand and conglomerate interbedded with basalt and volcanic tuff. The black basaltic sand is supposed to have the richest content of gold and platinum, but neither in panning the material in the field nor in the chemical tests made by the Geological Survey could any trace of platinum or other metals of the platinum group be found. Neither was any gold found in the concentrates, and it is concluded that material of this type is very unlikely to contain workable amounts of gold.

In conclusion, the Geological Survey desires to warn prospectors and investors against accepting at their face value any statements in regard to platinum-bearing ores and sands that do not show native platinum when panned. Such material should always be sent to assayers whose reputation is above reproach.

## HELP YOUR GOVERNMENT.

You may not be able, for good reasons, to go to the front and fight for your country; but you have often wanted to do something more for your country in time of war, and wondered how you could be of further service.

This letter is to tell you how you may serve your country NOW and all the time, and at the same time help yourself, help your children, and those who are near and dear to you.

The Government has extended the opportunity to aid in the successful financing of the war to every man, woman, and child in the United States. It wants everyone as a partner in the fight for democracy. For this purpose it has devised the WAR SAVINGS plan. Under it you can lend money to your Government by buying Thrift or War Savings Stamps, as little as twenty-five cents, and as much as $1,000—but no more.

There are two kinds of stamps, $5 War Savings and 25-cent Thrift Stamps. The War Savings Stamps sell from $4.12 to $4.23, according to the month in which purchased. These stamps are now on sale at every post office and sub-post office, most of the banks, and many other agencies. They are easy to buy, and are the most profitable Government loan offered to the public. Their return is equivalent to four per cent interest compounded every three months.

The Government wants you, your children, and all of your household to purchase stamps from your SURPLUS earnings—not what you have accumulated in the past, but what you can save in the future. It asks you to do without some of the things you think you want, and lend it the money you thus save. It wants you to be thrifty, so that you and your country may profit by your thrift.

If you give War Savings Stamps to your children you give something that will not only increase in value, but will induce them to save their pocket money in the coming year, and buy more. You will be teaching them a lesson in thrift, and letting them know that they, too, may serve their country.

If you make presents of these Stamps, besides aiding your country directly, you give indirect aid in that all labor employed in making the articles you think you need and don't, will be released to aid in the work of preparing the things the nation actually needs in the conduct of the war.

---

## REPORT OF THE DIRECTOR OF THE BUREAU OF STANDARDS.

Standardization is the keynote of the annual report recently made public by the Director of the National Bureau of Standards: "The Bureau occupies somewhat of the same position with respect to the manufacturing interests of this country that the bureaus of the Department of Agricultural do to the agricultural interests. Many industries are just beginning to realize the importance of precise methods of measurement and scientific investigation, which, in practically every case, involve some kind of measurement."

The services of the Bureau are in great demand and many researches have been completed or are in progress on points fundamental to the industries. "It is upon quality as well as upon price that competition must finally depend, whether in domestic or foreign commerce. The use of exact methods and scientific results is the greatest factor in the improvement of quality, efficiency, or the development of new industries. The educational value of the Bureau's work in this respect is almost entirely unknown to the general public, and yet the Bureau receives hundreds of letters, as well as many personal visits from manufacturers, seeking

information as to standards of measurement, how to use them, how to measure the properties of materials, or as to the fundamental, physical, and chemical principles involved; also, what is of even greater importance, how to initiate and carry out scientific investigations and tests on their own account in their particular fields of work."

The bulk of the report is devoted to a description of the investigations completed and in progress in the scientific and technical divisions of the Bureau.

In connection with the testing of railroad track scales the report states: "The Bureau has been cooperating in this work with the state and municipal weights and measures officials, with the weighmasters, manufacturers, railroads, private individuals, and other departments of the Federal Government, and steady progress is being made toward securing adequate standards in railroad track scale testing." Tests were made in twenty-eight states. "In these states 325 scales have been tested, of which 201, or 61.8 per cent, failed to pass the tolerance in condition in which they were found. The tolerance used by the Bureau is based on a maximum permissible error of weighing of 200 pounds in weighing a car of 100,000 pounds gross weight."

The Bureau's researches in heat included also important work upon the fire resisting properties of materials to furnish to architects, construction engineers, builders, state and city building bureaus, insurance interests, and others with fundamental engineering data relating to the behavior and safety of various types of building materials and construction when exposed to different conditions met with fires. Fire tests will be made of structural steel columns and reinforced concrete columns. Equipment of unusual interest installed during the year is the panel testing furnace which will be utilized for testing the fire resisting properties of building partitions and walls. In this connection a work of general interest is the investigation and formulation of data as to the building codes of the various states and cities.

The electrical testing included the inspection and testing of 1,250,000 electric lamps, a great variety of light standards, electrical instruments, standards, and materials. A matter of unusual interest has been the investigation and development of an instrument for finding the production of radio signals and using it for promotion of safety at sea.

## JOHN C. WINSTON COMPANY, PUBLISHERS.

The John C. Winston Company of Philadelphia announces that it will enter the schoolbook field on the 1st of January. For several years this company has been preparing a series of textbooks under the editorship of Dr. William Dodge Lewis, Principal of the William Penn High School of Philadelphia. James G. Stradling, for many years connected with The American Book Company, will be the salesmanager of this new Educational Department.

In the selection of authors and the treatment of the various subjects, Dr. Lewis has had the advice and active cooperation of a number of leaders in modern educational thought. Among them may be mentioned B. M. Watson, Secretary of the Public Education Association of Philadelphia, former Superintendent of Schools, Spokane, Wash.; Harold Barnes, Principal of the Elementary School, Girard College; and Dr. J. Lynn Barnard of the Philadelphia School of Pedagogy, a member of the National Education Association Committee on Social Studies.

The Winston Company, which in thirty years' experience has acquired a long list of publications, among which are many notable titles, has entered the educational field with a sincere effort to make a distinct contribution to textbook literature.

## ROCKS OF THE GRAND CANYON.

The visitor who looks into the Grand Canyon from the vicinity of El Tovar may, when the first overpowering impressions give place to particular observations, note the great series of nearly horizontal rock layers whose varied colors and cyclopean carving give beauty to what might otherwise be a gloomy and terrifying sight. He may perhaps wonder how these beds of rock were formed, how thick they are, and how long it took for them to pile up, inch by inch, on the bottom of a now vanished sea. He is not likely, however, unless he is a trained observer, to have his attention attracted by the dark, less conspicuous rocks in the very bottom of the canyon or to see that these are very different in many ways from the stratified rocks above them. Yet these rocks—mostly tough crystalline granite gneiss and schist—which the river, after cutting through thousands of feet of overlying beds, is now battering and grinding with its boulders, have an interesting story for those who may be able to read it. They are the oldest rocks in the canyon and, in fact, among the oldest in the world. They were in part deposited as sands and muds in a sea, in part accumulated as lava flows, and in part intruded beneath the surface as molten rock. All these materials became solidified, and later they were slowly heaved and crumpled into mountains which were in time worn down by rain, rivers, and perhaps the waves of the sea to a nearly level land surface. This surface finally sank beneath the sea and became the floor on which fresh sediments began to accumulate. Twice at least was this mighty cycle repeated in the Grand Canyon region.

Recently, in an attempt to work out some of the details of this ancient history, L. F. Noble, one of the geologists of the United States Geological Survey, Department of the Interior, studied them at several places on the south side of the river where, often with considerable difficulty, he was able to get down to them. His collections were studied microscopically by another member of the Survey, J. F. Hunter.

---

## ARTICLES IN CURRENT PERIODICALS.

*American Botanist*, for November; *Joliet, Ill.; $1.25 per year, 35 cents a copy:* "Fruit of the Potato," Willard N. Clute; "Uses of the Bayberry," Albert A. Hansen; "The Hawaiian Taro," Vaughan MacCaughey.

*American Journal of Botany*, for December; *Brooklyn Botanic Garden, New York City; $5.00 per year, 60 cents a copy:* "The Phytogeography of Manoa Valley, Hawaiian Islands," Vaughan MacCaughey; "Revision of the Hawaiian Species of the Genus Cyrtandra, Section Cylindrocalyces Hillebr," Joseph F. Rock; "On the Distribution of Abnormalities in the Inflorescence of Spiraea Vanhouttei," J. Arthur Harris.

*Geographical Review*, for December; *New York City, $5.00 per year, 50 cents a copy:* "Flanders," Raoul Blanchard; "A Journey on the Rio Zamora, Ecuador," J. L. Hermessen; "The Yuracaré Indians of Eastern Bolivia," Leo E. Miller; "The Peoples of Hungary," B. C. Wallis.

*Journal of Geography*, for January; *Madison, Wis.; $1.00 per year, 15 cents a copy:* "Humanizing High School Geography," Richard E. Dodge; "A Geographer's Geography Lesson On the Prairies," Albert P. Brigham; "Suggestions for Teaching Elementary Geography" (concluded), R. H. Whitbeck; "Prussianized Germany" (reprinted), Otto H. Kahn; "The Importance of Geographic Factors in the Birmingham, Ala., Iron District," Charles W. Cook; "Measuring the Ability of Children in Geography," E. E. Lackey; "Geography in the Junior High School," James H. Smith.

*Literary Digest*, for January 5; *New York City:* "The Government

Forced to Take the Railroads," "The Truth at the Bottom of the Sugar Barrel," "To Win the War with American Coal." For January 12: "Why Our Soldiers Wait for Clothes," "The Brewers' Campaign of Righteousness (?)," "A Peace Offer Distrusted by Both Sides."

*Photo-Era*, for January; *Boston, Mass.; $2.00 per year, 20 cents a copy:* "Exhibitions and Exhibitors," Sigismund Blumann; "Panoramic Cameras and Panoramic Perspective," Harold Munday; "Experiences in Amateur-Portraiture," Ralph Osborne; "On Stopping Down," Thomas Kingham; "Direct-Mail Methods for Photographers," Michael Gross; "Photographing Frost," R. A. Buchanan; "Making the Still-Life Picture," W. R. Bradford; "Buying a Second-Hand Lens," T. D. Percival.

*Popular Astronomy*, for January; *Northfield, Minn.; $3.50 per year:* "Beneath Midwinter's Starlit Dome," Charles N. Holmes; "Twenty-first Meeting of the American Astronomical Society," Concluded; "A Short Method of Utilizing Coincidence of Beats in Comparing and Setting Clocks," Charles C. Wylie; "A Reply to Professor Flint's Article, 'The American Ephemeris Tables of the Times of Rising and Setting of the Sun and the Moon—A Review,' " Arthur Newton; "Report on Mars, No. 19," William H. Pickering.

*The Psychological Clinic*, for December; *Philadelphia, Pa.; $1.50 per year, 20 cents a copy;* "A Brief Binet-Simon Scale," Edgar A. Doll; "A Case of Educational Retardation," Charles L. Harlan.

*School Review*, for January; *University of Chicago Press; $1.50 per year, 20 cents a copy:* "Foreign Languages and Mathematics as Requirement for Admission to, and Graduation from, American Colleges and Universities," E. E. Lewis; "The Social Core of the High-School Curriculum," Herbert G. Lull; "Elimination from the Public Secondary Schools of the United States," Frank G. Pickell and B. F. Winkelblech.

*School World*, for December; *Macmillan Company, London, Eng., 7s. 6d. per year:* "The Adjustment of the Secondary-School Curriculum, Walter Ripman; "How to Write with the Left Hand, II; The Characteristics of Left-Handed Script," P. B. Ballard; "Educational Aspects of the Kinematograph," H. O. Hale.

---

## SOAP PLANTS.

Now that the war has caused an increase in even the price of soap grease, a lively interest is being manifested in all sorts of saponaceous plants. One or two of these soap-yielding species have been articles of commerce for a long time, notably the soap bark derived from the South American trees, *Pithecolobium bigeminum* and *Quillaia saponaria*. A stock of this bark is carried by most drug stores. The soapberry (*Sapindus saponaria*) is also used for washing clothes in the tropics, but a little soap goes a long way in such places. The common bouncing Bet (*Saponaria officinalis*) gets its generic name from the soapy qualities of its juice, while its specific name would indicate that at some time it, too, was sold in shops. The substances in plants that give them their saponaceous qualities are called saponins. They are really glucosides, that is, substances which upon breaking up yield sugar and some other substance. With water all saponins form a froth or lather. Some are occasionally added to certain frothy liquids to help out the froth, incidentally making a barrel of the liquid last longer. Saponins have been found in more than a hundred species of plants. Among the plant families represented by saponaceous members are the Liliaceae, Dioscoreaceae, Araceae, Chenopodiaceae, Phytolacaceae, Caryophyllaceae, Berberidaceae, Magnoliaceae, Ranunculaceae, Bixaceae, Theaceae, Rutaceae, Zygophyllaceae, Meliaceae, Polygolaceae, Pittosporaceae, Rhamnaceae, Saxifragaceae, Passifloraceae, Bignoniaceae, Leguminosae, Primulaceae, Sapotaceae, Oleaceae, Solanaceae, Schrophulariaceae, Rubiaceae, and Compositae.—*American Botanist.*

## PROBLEM DEPARTMENT.

**Conducted by J. O. Hassler,**

*Crane Technical High School and Junior College, Chicago.*

*This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics. Besides those that are interesting* per se, *some are practical, some are useful to teachers in class work, and there are occasionally some whose solutions introduce modern mathematical theories and, we hope, encourage further investigation in these directions. All readers are invited to propose problems and solve problems here proposed. Problems and solutions will be credited to their authors. In selecting solutions for publication we consider* accuracy, completeness, *and* brevity *as essential. Address all communications to J. O. Hassler, 2301 W. 110th Place, Chicago.*

### Algebra.

536. *Proposed by Daniel Kreth, Wellman, Ia.*

Five gamblers, A, B, C, D, E, play together on the condition that he who loses shall give to each of the others as much as he already has. First A loses, then B, then C, then D, and finally E. At the end of the fifth game each has \$32. How much had each before they began to play?

I. *Solution by William F. Rigge, Omaha, Neb.*

Let the original amounts possessed by the players be respectively $a$, $b$, $c$, $d$, $e$. As the total sum is always the same, it follows that

$$a+b+c+d+e = 5\times 32 = 160 \text{ dollars.}$$

Then the horizontal data in the following schedule will show in reduced form the successive fortunes of each player, the vertical columns giving the results after each game.

| | | 1 | 2 | 3 | 4 | 5 | |
|---|---|---|---|---|---|---|---|
| A | $a$ | $2a-160$ | $2(2a-160)$ | $4(2a-160)$ | $8(2a-160)$ | $16(2a-160)$ | $=32$ |
| B | $b$ | $2b$ | $4b-160$ | $2(4b-160)$ | $4(4b-160)$ | $8(4b-160)$ | $=32$ |
| C | $c$ | $2c$ | $4c$ | $8c-160$ | $2(8c-160)$ | $4(8c-160)$ | $=32$ |
| D | $d$ | $2d$ | $4d$ | $8d$ | $16d-160$ | $2(16d-160)$ | $=32$ |
| E | $e$ | $2e$ | $4e$ | $8e$ | $16e$ | $32e-160$ | $=32$ |

In this way the values of the five unknowns are easily found, being respectively, 81, 41, 21, 11, 6.

The problem may be generalized by letting $n$ = the number of players, and $m$ = the equal sum each has at the end. Then

$$a+b+c+d+e = mn.$$

At the end of the game we have the above fifth column modified into

$$\begin{array}{rcl} 16(2a-mn) & = & m \\ 8(4b-mn) & = & m \\ 4(8c-mn) & = & m \\ 2(16c-mn) & = & m \\ 32e-mn & = & m \end{array} \quad \text{whence} \quad \begin{array}{rcl} a & = & (2^4n+1)m/2^n \\ b & = & (2^3n+1)m/2^n \\ c & = & (2^2n+1)m/2^n \\ d & = & (2n+1)m/2^n \\ e & = & (n+1)m/2^n \end{array}$$

If $m$ is taken equal to $2^n$, it will have its minimum integral value. This has been done in the present problem.

If we now add up our values of $a$, $b$, $c$, $d$, $e$, we get

$$mn = n(1+2+2^2+2^3+2^4)+n$$

$$\text{or } m = (1+2+2^2+2^3+2^4)+1.$$

The parenthesis is a geometrical progression, in which, in general, if $a$ is the first term, $r$ the ratio, and $n$ the number of terms, then $s$, their

sum, equals $(ar^n-a)/(r-1)$, so that in this case the parenthesis is equal to $2^n-1$, and $m = 2^n$, as said before.

If we take seven players, $n = 7$, and $m = 2^7 = 128$, the lowest integral number of dollars that can be possessed by the players at the end of the game. Two terms are then to be added to the five former ones, $2^5n+1$ and $2^6n+1$, so that the original sums must be 449, 225, 113, 57, 29, 15, 8. This is the problem as it is given by Loomis in his *Treatise on Algebra (1881)*, page 112 (No. 12) where, however, instead of players and dollars, he uses seven baskets of apples, taking apples from each basket in turn and with them doubling those in the other baskets.

II. *Solution by Gertrude Buck, Adrian, Mich.*

Let $a$, $b$, $c$, $d$, and $e$ represent the number of dollars owned before the game by A, B, C, D, and E, respectively.

Then

$16(a-b-c-d-e)$ = the amount held by A at close of 5th game.
$24b-8(a+c+d+e)$ = the amount held by B at close of 5th game.
$28c-4(a+b+d+e)$ = the amount held by C at close of 5th game.
$30d-2(a+b+c+e)$ = the amount held by D at close of 5th game.
$31e-(a+b+c+d)$ = the amount held by E at close of 5th game.

Since at the close of the game each has \$32 we have the system of equations formed by making each of these sums equal to 32.

Then

$$\begin{aligned} a- b- c- d- e &= 2 \\ -a+3b- c- d- e &= 4 \\ -a- b+7c- d- e &= 8 \\ -a- b- c+15d- e &= 16 \\ -a- b- c- d+31e &= 32 \end{aligned}$$

Solving these equations we find

$$a = 81, \quad b = 41, \quad c = 21, \quad d = 11 \quad \text{and} \quad e = 6.$$

III. *Solution by Arthur Bergman, Milwaukee, Wis.*

After the 5th game each gambler had \$32.00.
After the 4th game A, B, C, and D, each had \$16.00.
After the 3rd game A, B, and C, each had \$8.00.
After the 2nd game A and B had \$4.00.
After the 1st game A had \$2.00.

Let $a$, $b$, $c$, $d$, and $e$ be the amounts A, B, C, D, and E, respectively, had before they began to play.

$\therefore$ From above

$$a+ b+ c+ d+ e = \$160 \qquad (1)$$

As a result of the 1st game A had \$2, while each of the others doubled his amount.

$$\therefore \quad 2+2b+2c+2d+2e = \$160 \qquad (2)$$

As a result of the 2nd game A and B each had \$4, while each of the others doubled his amount.

$$\therefore \quad 4+4 \ +4c+4d+4e = \$160 \qquad (3)$$

As a result of the 3rd game A, B, and C each had \$8, while each of the others doubled his amount.

$$\therefore \quad 8+8 \ +8 \ +8d+8e = \$160 \qquad (4)$$

As a result of the 4th game A, B. C, and D each had \$16, while E doubled his amount.

$$\therefore \ 16+16+16+16+16e = \$160$$
$$\therefore e = \$ \ 6$$

By substitution, from (4) $d$ = \$ 11
By substitution, from (3) $c$ = \$ 21
By substitution, from (2) $b$ = \$ 41
By substitution, from (1) $a$ = \$ 81

IV. *Solution by Murray J. Leventhal, New York City.*

At the end of the fourth game, each of the first 4 gamblers evidently had \$16 and E, $32+4\times16 = 96$. Since E's amount is halved at the end of each preceding game, his initial sum $= 96/2^4 = 6$. At the end of the 3rd game, A, B, C have \$8 each. D, therefore, has $48+3\times8+16$ or 88; his first sum $= 88/2^3 = 11$. At the end of the 2nd game, C's share $= 44+24+2\times4+8 = 84$ and his original sum $= 84/2^2 = 21$. Similarly, A and B had \$81 and \$41, respectively, before they began to play.

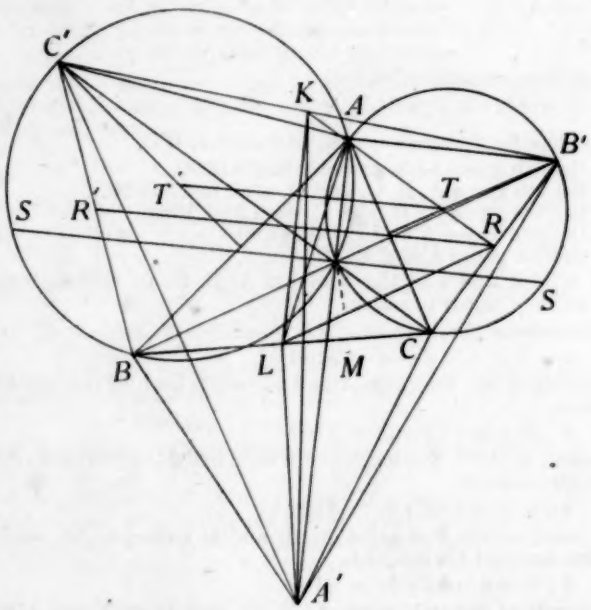
Solutions to this problem were also received from *Ruth A. David, Isidore Ginsburg, J. W. Holman, Caroline Lefkowitz, Mabel McLaughlin, Sidney Nierman, Nelson L. Roray* (2). One solution with unknown author—*please read and observe rules* published in earlier numbers. —*Editor.*

## Geometry.

537. *Proposed by Nelson L. Roray, Metuchen, N. J.*

Equilateral triangles are constructed outwards upon the sides of any triangle. Prove by elementary geometry only that the given triangle and the triangle whose vertices are the outermost vertices of the equilateral triangles have the same median point.

*Solution by Nelson L. Roray, Metuchen, N. J.*




Let ABC be the given triangle; A′, B′ and C′ the vertices of the constructed triangles; T the circumcenter of AB′C, T′ of ABC′; AL median of ABC, A′K of A′B′C′; R mid point of B′C, R′ of BC′; S mid point of arc B′C, S′ of BC′; M the point of intersection of AA′, BB′ and CC′ (Problem 348, Nov., 1913).

Then $TT' \perp AM$, $TT' \parallel SS'$ and $RR' \parallel SS'$ $\therefore RR' \perp AM$ . (1)

$KR \parallel CC'$ and $KR = \frac{1}{2} CC'$; $LR \parallel BB'$ and $LR = \frac{1}{2}BB'$ (2)

$\therefore \angle KRL = \angle C'MB = 60°$.

Since KRLR′ is a parallelogram KL and RR′ bisect each other, also $\angle KRR' = \angle SMC = 30°$.

$\therefore \triangle KRL$ is equilateral. (3)

and RR′ $\perp$ KL and KL $\parallel$ AA′, from (1).

If Z is mid point of AC and Z′ of A′C,

$\triangle ZZ'C \cong \triangle LCR$ and ZZ′ = LR $\therefore$ AA′ = BB′. (4)

and AA′ = BB′ = CC′ from (2), (3) and (4).

Since KL = LR = $\frac{1}{2}$BB′

$\therefore$ KL = $\frac{1}{2}$AA′

$\therefore$ In trapezoid KLAA′ LA and KA′ trisect each other and this point of trisection is the median point of each triangle.

538. *Proposed by N. P. Pandya, Sojitra, India.*

Construct a triangle ABC, having given angle B, median from C on AB, and the angle between the median and the perpendicular from A on BC.

I. *Solution by Ruth A. David, Gibson City, Ill.*

Let $m$ be the given median, and $\angle x$, the acute $\angle$ between the median and the $\perp$ from A on BC.

Construction:

1. Construct CE = $m$.
2. Construct $\angle ECH$ equal to the complement of $\angle x$.
3. At any point H in line CH construct $\angle CHG$ = given $\angle B$.
4. Through E construct a $\parallel$ to HG meeting CH at B.
5. Extend BE to A, making EA = BE.
6. Draw AC.

Triangle ABC is the required $\triangle$.

The proof follows easily from the figure.

II. *Solution by Nelson L. Roray, Metuchen, N. J.*

Construct $\angle MBN = \angle B$. Upon side BN construct NR $\perp$ BN. At S, any point on NR, construct $\angle TSN$ = angle formed by median and perpendicular. Let TS intersect BM at T and BN at E. (Angle TSN must be obtuse for the problem to be possible as is easily proved.)

Then construct $\triangle T'E'B'$ with T′E′ equal to given median, $\angle E' = \angle E$, and $\angle T' = \angle T$ of $\triangle TEB$. Evidently T′B′ = $\frac{1}{2}$AB, B′S′ = BC and the rest of the construction follows at once.

Note: This method holds whether $\angle B$ is acute, right or obtuse, but $\angle TSN$ must always be obtuse.

III. *Solution by Murray J. Leventhal, New York City, and Joe Kuckuck, Martin's Ferry, O.*

Let altitude AE and median CD meet in F. Whether $\angle BCA$ is acute or obtuse, $\angle FCE$ is the complement of the given $\angle AFD$. $\therefore \triangle BCD$ is easily constructed (2 sides and the included $\angle$). Now make DA = BD and join A to C. The proof is evident from the diagram.

539. *Proposed by Sam I. Jones, Nashville, Tenn.*

Given an angle and a point without its sides to draw through the point a line cutting the sides of the angle, forming a triangle whose perimeter equals the length of a given line.

*Solution by E. L. Brown, Denver, Colorado, Nelson L. Roray, Metuchen, N. J., and Murray J. Leventhal, New York City.*

Let AM, AN be the two given lines, and P the given point.

Measure off AD on AM and AE on AN so that AD = AE = S. one-half length of given line.

Let O be center of circle tangent to AM and AN at D and E, respectively.

Through P draw a line tangent to circle at T and cutting AM in B and AN in C; this tangent line to lie between A and O.

ABC will be the triangle required.

$AB+BT = AB+BD = s$

$AC+CT = AC+CE = s$

$\therefore AB+BT+TC+AC = AB+BC+AC = 2s.$

540. *Proposed by Daniel Kreth, Wellman, Ia.*

Construct the triangle if the three radii of the escribed circles are given.

I. *Solution by E. L. Brown, Denver, Colorado.*

We will assume relations expressed by (1), (2), (3).

$$r = \frac{\triangle}{s},\ r_1 = \frac{\triangle}{s-a},\ r_2 = \frac{\triangle}{s-b},\ r_3 = \frac{\triangle}{s-c}. \tag{1}$$

$$\frac{1}{r} = \frac{1}{r_1}+\frac{1}{r_2}+\frac{1}{r_3} \quad . \ . \ . \ (2) \qquad \triangle = \sqrt{rr_1r_2r_3}. \tag{3}$$

Since $r_1$, $r_2$, $r_3$ are given, $r$ may be constructed as follows: Let A, B, C, be three points on a straight line. On same side of this line erect $\perp$s AD, BE, CF, equal, respectively, to $r_1$, $r_2$, $r_3$.

From G, intersection of AE and DB, drop GH $\perp$ to AC.

From K, intersection of GC and HF, drop KL $\perp$ to AC.

It is easily proved that

$$\frac{1}{GH} = \frac{1}{r_1}+\frac{1}{r_2}, \text{ and } \frac{1}{KL} = \frac{1}{GH}+\frac{1}{r_3} = \frac{1}{r_1}+\frac{1}{r_2}+\frac{1}{r_3}.$$

$\therefore KL = r$, radius of inscribed circle.

From (2) and (1),

$$\frac{1}{r}-\frac{1}{r_1} = \frac{1}{r_2}+\frac{1}{r_3} = \frac{s-b}{\triangle}+\frac{s-c}{\triangle} = \frac{a}{\triangle}. \tag{4}$$

$$\therefore a = \triangle\left(\frac{1}{r_2}+\frac{1}{r_3}\right) = \triangle\left(\frac{1}{r}-\frac{1}{r_1}\right). \tag{5}$$

From (3) and (5),

$$a = \sqrt{rr_1r_2r_3}\left(\frac{r_2+r_3}{r_2r_3}\right) = \sqrt{rr_1r_2r_3}\left(\frac{r_1-r}{rr_1}\right).$$

$$\left.\begin{aligned} \therefore a^2 &= (r_2+r_3)(r_1-r) \\ \text{Similarly, } b^2 &= (r_3+r_1)(r_2-r) \\ \text{and } c^2 &= (r_1+r_2)(r_3-r) \end{aligned}\right\} \tag{6}$$

Hence, sides of required $\triangle$ are mean proportionals between sums and differences of radii of inscribed and escribed circles, as indicated in (6).

II. *Solution by Nelson L. Roray, Metuchen, N. J.*

Let $r_1$, $r_2$, and $r_3$ be the radii of the escribed circles upon the sides $a$, $b$, and $c$, respectively; $r$ the radius of the incircle, I its center; $R$ the radius of the circumcircle, S its center.

The following well known formulae enable us to determine $r$, $R$, $\angle C$ and SI.

$$\frac{1}{r_1}+\frac{1}{r_2}+\frac{1}{r_3} = \frac{1}{r}$$

$r_1+r_2+r_3-r = 4R$
$r+r_1+r_2-r_3 = 4R\cos C$
$SI^2 = R^2-2Rr.$

Construct angle = $\angle C$; then circle, center I, of radius $r$, tangent to the sides of $\angle C$. With SI as radius and center I construct a circle. This circle is locus of S with respect to I. With C as center and radius SI construct a circle (locus of S with respect to C). The intersection of these locii determines S. The rest of the construction follows at once.

Note: The two locii in general intersect in two points giving two circumcenters. The two triangles formed, however, will be congruent.

### Solution Received.

*A solution to 528 was received from N. P. Pandya too late for publication.*

---

## PROBLEMS FOR SOLUTION.

530. *Proposed by N. P. Pandya, Sojitra, India.*

(*This is repeated—no solutions received.—Ed.*)

If $\sin^4\theta+\sec^2\theta+\tan^2\theta = \cos^2\theta+\csc^2\theta$, find $\sin 2\theta+\cos 2\theta$.

### Algebra.

551. *Proposed by Murray J. Leventhal, New York City.*

Show that the sum of the squares of the reciprocals of the natural numbers is $\frac{1}{6}\pi^2$.

### Geometry.

552. *Proposed by Norman Anning, France.*

Given a regular $n$-gon, to construct a regular $2n$-gon having the same center and the same length of side.

553. *Proposed by W. W. Gorsline, Chicago.*

Of all possible triangles inscribed in a given segment the isosceles triangle has the maximum perimeter.

554. *Proposed by the Editor.*

Prove by a direct method that if two angle bisectors of a triangle are equal the triangle is isosceles.

[This theorem being a familiar one, a recently published solution by Dr. Artemas Martin in the *American Mathematical Monthly* attracted our attention and it is desired to make a collection of different direct methods. Send also copied methods (with references).—*Editor.*]

### Trigonometry.

555. *Proposed by Daniel Kreth, Wellman, Ia.*

Determine a point P within a triangle ABC such that the angles PAB, PBC, PCA, shall be equal.

---

The special campaigns in the South for the increased production of foodstuffs through the extension forces resulted in a marked increase in the planting of corn, soy beans, velvet beans, cow-peas, peanuts, sweet potatoes, Irish potatoes, and other food crops. The corn crop in the fifteen Southern States was 964,504,000 bushels, or more than a fourth of the whole crop of the United States.

## SCIENCE QUESTIONS.

Conducted by FRANKLIN T. JONES,
*University School, Cleveland, Ohio.*

*Readers are invited to propose questions for solution—scientific or pedagogical—and to answer questions proposed by others or by themselves. Kindly address all communications to Franklin T. Jones, University School, Cleveland, Ohio.*

**Please send examination papers on any subject or from any source to the Editor of this department.** *He will reciprocate by sending you such collections of questions as may interest you and be at his disposal. Send your first term examination papers now.*

### Examination Papers.

A number of years ago the Editor of this department collected examination papers in physics from about one hundred high schools. These papers were edited, and selected questions to the number of 370 were published—credit in each case being given—as the Appendix, pp. 389-422, to Crew & Jones' *Elements of Physics*. The collection of examination papers by that method requires a large expenditure of time and some expense.

Readers of SCHOOL SCIENCE AND MATHEMATICS are again urgently requested to send their first semester examination papers to the Editor. He hopes to publish many papers, especially such as will be suggestive not only in physics, but in chemistry, biology, general science, etc.

PLEASE HELP!

### Questions and Problems for Solution.

291. *Proposed by the Editor.*

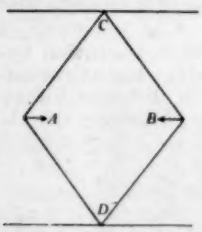
I. Which is the method to be preferred in testing the results of physics teaching:

(*a*) That of the School Survey which seeks to find out whether or not the subject is being taught successfully, or

(*b*) That of practice tests such as Courtis in arithmetic and Rugg and Clark in algebra?

II. Is it correct to say that (*a*) tests *knowledge* and (*b*) *attainment*?

III. In proposing physics tests, what *abilities* do we wish to investigate?




292. *Proposed by J. P. Drake, Emporia, Kan.*

If all the arms are of equal length, find thrust in each arm when angles at C and D are 60°. Also find force tending to separate C and D.

293. *Asked by O. L. Brauer, Selma, Cal.*

Have any data been published as to how the radiation from a hot sphere varies with the time?

294. *From "An Elementary Study of Chemistry," by McPherson and Henderson (Ginn & Company, 1917).*

The heat evolved in the slacking of 100 kg. of lime would raise the temperature of what weight of water from room temperature (say 18°) to boiling?

## Solutions and Answers.

266. *Proposed by A. H. Smith, Riverside, Cal.*

The nozzle of a fire hose has an opening 2 in. in diameter while the pipe just back of it is 3 in. in diameter. Find the pressure just back of the nozzle when it can throw a jet 60 ft. vertically upward.

*Solution by J. P. Drake, Emporia, Kan.*

Let $v_1$ = veloc. in 3 in. tube.
$v_2$ = veloc. in 2 in. tube.
$m$ = mass of water.
Neglecting atmospheric pressure,

1. $mgh + 1/2\ mv_1^2 = 1/2\ mv_2^2$.
2. $v_2^2 = 2 \times 32.2 \times 60 = 62.2$ ft. per sec.
3. $v_1 = \left(\frac{2}{3}\right)^2 \times 62.2 = 27.64$.
4. Substituting in 1.

$gh + 382 = 1{,}932$.
$\therefore h = 48+$.

$$\therefore \text{pressure} = \frac{48}{144} \times 62.4 = 20.8+ \text{ lbs. per sq. in.}$$

Since this pressure is opposed to atmospheric pressure, the absolute pressure $= 20.8+ + 14.7 = 35.5+$ lbs. per sq. in.

270. *Proposed by William T. Reed, Woodlawn, Pa.*

Will a boat sunk in midocean ever reach the bottom? If it does reach the bottom, what principles of physics are involved? If it does not reach the bottom, state why.

*Answered by F. T. Jones.*

The boat will reach the bottom if its specific gravity exceeds that of the sea water at the depth. Water being only slightly compressible, its specific gravity is always less than 2. At a depth of two miles the specific gravity of sea water is about 1.4. The principle is that of Archimedes, namely, that any body will sink in a liquid of lower specific gravity because it displaces a weight of liquid less than its own weight. Hence, there is a resultant force downward.

272. *Proposed by Ross A. Baker, Minneapolis, Minn.*

What volume of $H_2SO_4$ (sp. gr. = 1.84) and what weight of NaCl would be required to produce the HCl present in 8 kgm. of a 3 per cent solution of HCl?

*Solved by the Editor.*

8 kgm. = 8000 gm.
$8000 \times .03 = 240$. gm. wt. of HCl formed.
Assuming a high temperature,

$$H_2SO_4 + 2NaCl \rightarrow Na_2SO_4 + 2HCl.$$
$$98 \quad + \quad 117 \qquad\qquad 73$$
$$x \text{ gm.} \quad + \quad y \text{ gm.} \qquad\qquad 240 \text{ gm.}$$

$$\frac{98}{x} = \frac{73}{240}. \qquad \frac{117}{y} = \frac{73}{240}.$$

$x = 322$ gm. $H_2SO_4$. $\qquad y = 384.6$ gm. NaCl.

$322 \div 1.84 = 175$ c.c. $H_2SO_4$.

274. *From a Princeton Examination.*

How much carbon dioxide by weight and by volume, at 21° and 755

mm., could be obtained by treating 8 grams of pure calcium carbonate with an excess of hydrochloric acid?

(Note.—A liter of carbon dioxide at 0° C. and 760 mm. weighs 1.977 g.)

*Solution.*

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

100 44

8 gm. $x$ gm.

$$\frac{100}{8} = \frac{44}{x},$$

$$x = 3.52 \text{ gm. } CO_2.$$

$$3.52 \div 1.977 = 1.780 \text{ l. at } 0°, 760 \text{ m. m.}$$

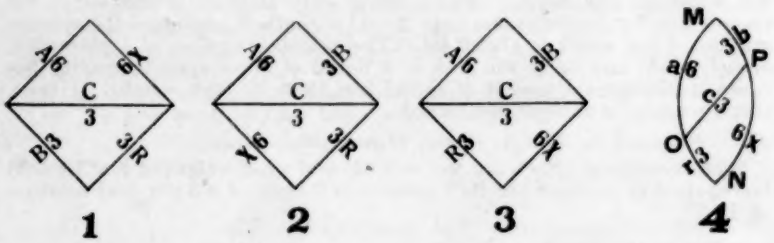
$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}, \text{ or } \frac{760 \times 1.780}{273+0} = \frac{755x}{273+21}.$$

$$x = \frac{294 \times 760 \times 1.780}{273 \times 755} = 1.929 \text{ l.}$$

277. *Proposed by W. H. Magill, Westtown, Pa.*

In a Wheatstone bridge the A arm has a resistance of 6 ohms, the R arm 3 ohms, the B arm 3 ohms, the X arm 6 ohms, and the galvanometer is replaced by a resistance of 3 ohms. What is the total resistance between the battery binding posts of the bridge, and what current flows through the 3 ohms which replace the galvanometer when an E. M. F. of 9 volts is used?

*Another solution and discussion by Wm. F. Rigge, Creighton University, Omaha, Neb.*




The problem is vaguely worded. Which of the figures, 1, 2, or 3, here given, is meant, the battery wires in all cases being connected to the top and bottom? Is it No. 1, as the four solvers take it? If so, the sequence of the letters A, R, B, X is not observed, and the problem is too elementary for these pages. If it is No. 2, the sequence is again violated, and the solution given does not fit the case, because the resistances of the two circuits, AX and BR, are not equal. If it is No. 3, the sequence of the letters is most probably the one intended by the proposer, and the problem becomes worth the time a science teacher may devote to it.

Let us transform Figure 3 to 4, and use small letters to denote the volts in the branch circuits, the numbers being the ohms, and let us put large ones at the junction points, M and N being, as before, the battery terminals. As P is at a higher potential than O, a current will run through the coil C from P towards O. The total current is then equal to

$$\frac{a}{6}+\frac{b}{3}=\frac{r}{3}+\frac{x}{6}=\frac{a}{6}+\frac{c}{3}+\frac{x}{6},$$

because the current in B is equal to the two in C and X, and therefore

$$\frac{b}{3}=\frac{c}{3}+\frac{x}{6}.$$

The partial currents are the one last mentioned, and

$$\frac{r}{3}=\frac{a}{6}+\frac{c}{3}.$$

We also have the voltages (9 being the total),

$$a+r=b+x=b+c+r=9.$$

Solving these equations we find the volts

$$a=x=\frac{36}{7},\ b=r=\frac{27}{7},\ c=\frac{9}{7},$$

and the amperes in A and X 6/7, in B and R 9/7, and in the coil C 3/7, and the total current = 15/7. The total resistance between the battery terminals M and N is then

$$9\div\frac{15}{7}=\frac{21}{5}=4.2 \text{ ohms}.$$

*Remarks by W. A. Tippie.*

As to the Wheatstone bridge problem, Mr. Rigge has given a very interesting discussion of it. By changing the ordinary interpretation of the problem, he has made a real problem out of it, and has solved it. I shall be glad to see his discussion published in the *Science Question Department.*

281. *Submitted by Philo F. Hammond, University of Alberta, Edmonton South.*

The Editor suggests a careful comparison of the following examination paper with the College Entrance Examination Board paper published in October, 1917, SCHOOL SCIENCE AND MATHEMATICS.

Which is the easier? Which more nearly represents the attainment desired in pupils of high school age?

Is thinking in terms of mathematical relations (emphasized by the Board) more natural to the student of high school age than thinking in terms of verbal description (emphasized by Alberta)? Which is more desirable from a pedagogical point of view?

Are our efforts at teaching young students mathematical physics wisely expended?

Is it unpedagogical to teach physics in such a way that pupils will like it? Do they like mathematical physics?

*A comparison of a College Board and Alberta physics examination by J. P. Drake, Emporia, Kan.*

It is difficult to compare the two papers as to the amount of mathematics used, since one covers the entire field and the other is confined to magnetism and electricity and sound. Mechanics, heat, and light are more often treated mathematically.

Except for the above consideration the Board test is decidedly mathematical, and the Alberta test decidedly qualitative. The qualitative treatment appeals more to the student of high school age and experience than does the quantitative.

A better plan is to make the larger part of the work qualitative, but introduce enough of the mathematics to enable the student to grow in his ability to handle mathematical formulas and to see the value of a definite mathematical statement.

## IOWA ASSOCIATION OF MATHEMATICS TEACHERS.

The 1917 meeting of the Iowa Association of Mathematics Teachers was held in Room 201, East Des Moines High School, Friday, November 2, at 2 p. m.

After the call to order by President F. K. Williamson, Chariton High School, an unusually strong program was presented.

The Publicity Committee report was given by the Chairman, Principal W. E. Beck, Iowa City High School. This committee distributes each year to the membership, copies of valuable reports and other publications of interest to teachers of mathematics. This year eight different reports and reprints were given out.

The first report of the committee on an "Iowa Syllabus of Secondary Mathematics" was presented in mimeographed copies, by the Chairman, W. S. Lines, Mason City High School. The other members of the committee are: Maria M. Roberts, Iowa State College, Ames; F. H. Stewart, North Des Moines High School; Helen M. Walker, Ottumwa High School; Lois Karr, Indianola High School. The report was adopted and the committee continued for further investigation.

The report on "Elimination of Subject Matter in Arithmetic," as given at the 1916 meeting of the Iowa State Teachers Association, was discussed by C. W. Wester, Iowa State Teachers College.

At this point in the program, the Iowa Section of the Mathematical Association of America, which was holding its meeting in an adjoining room, came in to hear the address by Professor W. W. Hart, University of Wisconsin, on "More Practical Matters As to Methods and Modes in Teaching Mathematics." This was an extremely practical, as well as an intensely interesting, presentation of this topic. The address was followed by questions and discussion.

The Nominating Committee reported the following officers for the coming year:

President—E. E. Watson, Parsons College, Fairfield, Iowa.

Vice-President—Maria M. Roberts, Iowa State College, Ames, Iowa.

Secretary-Treasurer (three-year term)—Ira S. Condit, Iowa State Teachers College, Cedar Falls, Iowa.

The report was adopted.

IRA S. CONDIT,
*Secretary.*

---

## CONSERVATION OF COAL.

As a means of far-reaching economy the Government should at this time apply intelligent and direct-acting efforts to the conservation of fuel at the industrial plants which are responsible for its greatest consumption. It is unnecessary before a body of engineers to show proof that coal is wasted in vast quantities in the boiler furnaces of many plants, to feed which it is mined and distributed at a high and ever-increasing cost of labor and material.

The mining and distribution of coal has been placed under the supervision of a War Coal Board in order more nearly to meet the crying needs in these directions, and to apportion the coal in quantity and to uses deemed most expedient.

While this organized effort to bring about efficiency in the production and distribution of coal is being made, no parallel measures have been adopted to bring about a normal and practicable efficiency in its use. The hundreds of large plants which are consuming fuel wastefully are directly and needlessly causing a large fraction of the existing car shortage.

They are overloading the already strained capacity of the railroads; they are rendering slower and more difficult the transportation of food and other vital commodities; and in short they are simply counteracting the measures of efficiency in production and distribution which have elsewhere been established.

### Preventable Waste of Fuel.

The preventable waste of fuel in the boiler furnace of one steel mill amounted to 40,000 tons per year, which at $5 a ton would cost $200,000. This was a comparatively modern plant. The efficiency of boilers and furnaces in a fourteen-day test was fifty-five per cent. The load factor was unusually favorable to high efficiency and could readily be raised to seventy per cent or over. This is only one example, and there are many more extreme cases.

The saving or wasting of one-fourth of the coal consumption of any industrial plant depends entirely upon the efficiency of its operating management. This fraction of the consumption relates exclusively to the boiler plants, i. e., the production of steam, and does not include the large economies possible in connection with its distribution and use.

Under present conditions a plant which carelessly operates at an efficiency of forty to fifty per cent receives from the Government the same consideration in the delivery of coal as the one whose efficiency is seventy to seventy-five per cent. This obviously is unfair as well as wasteful.

The Government hands over, say, 200,000 tons of coal a year to a plant owner, but asks for no account as regards its consumption, nor any questions as to the amount of steam it is made to produce. There is, nevertheless, an equivalent amount of steam this fuel is capable of generating, and it can and should be made to produce that quantity.

In general, there are two plans of operation worthy at least of consideration. One might be termed the autocratic method. This would involve the use of authority to compel coal consumers to execute such measures of economy as the proper authorities might prescribe for any given case. Limits to be set as to expense to the user. Such limits might be in terms of a percentage of their present yearly coal bill. Alterations to be directed chiefly, as previously implied, to purely operating improvements. Many objections would probably be made by consumers against this plan, but once in effect the majority would no doubt realize its pecuniary advantage to themselves. But its tendency may be too strongly opposed to democratic principles.

The other plan would be largely an educational one, in which patriotism and efficiency would furnish the motive forces required.

The teaching must be accomplished with the utmost simplicity and directness. Above all it must be in such form as to be readily comprehended and applied.

The U. S. Bureau of Mines has for a number of years engaged in obtaining and disseminating scientific information regarding the mining and consumption of coal, and the results of the work have been of great value to technical engineers who are able to use and apply it. It is evident that we now require an extension of the idea of education, but in such form as directly to affect the men who run the boiler plants of our country, for in their hands is the saving or wasting of one-fourth of our fuel supply.

Six hundred million tons of coal were mined in the United States in 1916. If we assume only one-half of this to have been used for our industrial boiler plants, then a quarter of the coal used under boilers amounts to 75,000,000 tons per year. It is worth while to save this fuel by preventing its waste. This quantity of coal represents the use of 1,500,000 fifty-ton freight cars.

## GENERAL MINUTES OF THE 1917 MEETING OF CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS.

The seventeenth annual meeting of the Central Association of Science and Mathematics Teachers was held at the University of Ohio, Columbus, Ohio, November 30 and December 1, 1917. A fine spirit of hospitality was manifest throughout the whole convention and the splendid facilities and complete arrangements for the comfort and convenience of the members were evidences of the labor and forethought of the local committee.

Friday morning the delegates were cordially welcomed to the city by Hon. George J. Karb, mayor of Columbus. Professor Charles H. Smith of Hyde Park High School ably responded for the Association. The main addresses of the morning were given by Dr. William Oxley Thompson, President of Ohio State University, on "Immediate and Ultimate Aims of Science and Mathematics Teaching" and Dr. L. H. Bailey of Cornell University on "Science Element in Education." These addresses are printed in full in the Proceedings.

Friday afternoon was devoted to Section programs, inspection of exhibits, and an informal reception in the University library. At the preliminary meeting Friday evening, Vice-President Harry D. Abells presided and the reports of the members of the Committee on "Science in the High School of Tomorrow" were presented. Mr. B. J. Rivett of Detroit, Mich., discussed the subject in its relation to Physics, and Miss F. B. Hunter of the University of Chicago in its relation to Home Economics. In the absence of Mr. H. B. Shinn of Chicago, Miss Nellie M. Cook of Springfield, Ill., read his report on "Biology in the High School of Tomorrow"; in the absence of Mr. H. N. Goddard of Madison, Wis., Mr. F. T. Jones read his paper on "Nature Study in the Seventh, Eighth, and Ninth Grades." Mr. W. R. McConnell of Platteville, Wis., read a paper from Mr. J. H. Smith of Chicago on "The Necessity of Geography in the High School." Chairman Franklin F. Jones briefly summarized the work of the committee and presented charts showing the possible arrangement of science courses from the seventh to the twelfth grades. It was moved and carried that the committee be continued for one year, and two additional members were added to the committee.

The lecture of the evening was given by Dr. Robert F. Griggs of Ohio State University, on "Katmai and the Ten Thousand Smokes." Dr. Griggs has recently returned from Alaska where he made explorations under the auspices of the National Geographical Society. It is unfortunate that copyrights owned by this society make it impossible for the Association to publish this interesting number in full.

Saturday morning was given over to routine business. The minutes of the 1916 meeting were read and approved. The Auditing Committee reported that the Treasurer's books were correct. The Treasurer's report was read and accepted. In the absence of Mr. E. L. Mahaffey, the Treasurer read the report of the Membership Committee and the list of new members to be voted in. Sixty-five new members were added to the Association. The following committees also presented reports: Necrology, Advertising, and Railroad and Steamship Maps. In the absence of Mr. H. L. Terry of Madison, Wis., Mr. H. R. Smith of Chicago read the report of the Committee on Resolutions, which follows:

"Realizing the tremendous significance of the principles involved in the present world conflict, the Central Association of Science and Mathematics Teachers in convention assembled at Columbus, Ohio, November 30 and December 1, 1917, publish the following resolutions:

"Resolved:

"I. That we affirm our trust and confidence in the wisdom and management of America's entry into and service in the present war.

"II. That we heartily support President Wilson and all the branches of the Government in the successful prosecution of the war.

"III. That we, as teachers, are not content to 'do our bit' but we will *do our utmost* in advancing efficient education.

"IV. That it is imperative that we, as teachers, look ahead and consider what our present pupils must do when they take up life work in the reconstruction period after the war.

"V. That we urge our membership and all teachers to beware of false economy in limiting growth in the ideals and inspirations of teaching.

"Be it further Resolved: That we mark with sorrow and regret the demise of a former honored President, James F. Millis, and that we will cherish his memory by increased devotion to the cause of progressive education, of which he was a most faithful exponent.

"Be it further Resolved: That we acknowledge our appreciation of the cordial welcome given by the city of Columbus, through Mayor George J. Karb and by the University of Ohio, and through President William Oxley Thompson.

"That we offer our sincere thanks of appreciation to the speakers of the General Session, President Thompson, Dr. Bailey, and Dr. Griggs, for their inspiring addresses.

"That we also thank all others who have contributed to our comfort and entertainment, Mr. and Mrs. George Arp at the reception, the newspapers of Columbus for their publication of the Association meetings.

"That we commend the activity of the Committee on the High School of Tomorrow and recommend that it continue its work in the light of changing content and methods in education.

"The committee begs to submit the following suggestions as a general theme for the year 1918: 'The educational demands of an awakened democracy.'"

H. R. SMITH,
C. E. COMSTOCK,
MISS JESSIE CAPLIN,
*Committee.*

The Nominating Committee reported the following:

President—Harry D. Abells, Morgan Park Academy, Morgan Park, Ill.

Vice-President—William M. Butler, Yeatman High School, St. Louis, Mo.

Treasurer—John H. McClellan, Harrison Technical High School, Chicago.

Assistant Secretary—D. A. Lehman, Goshen College, Goshen, Ind.

Assistant Treasurer—M. F. Wadleigh, South Division High School, Milwaukee, Wis.

HERBERT E. COBB,
*Chairman.*

It was moved and carried that the Secretary be instructed to cast the ballot of the Association for the officers named and they were declared duly elected.

Invitations from Cincinnati and Chicago for the 1918 meeting were read and the matter was referred to the Executive Committee.

A. W. CAVANAUGH,
*Secretary.*

TREASURER'S REPORT OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS FOR THE YEAR ENDING NOVEMBER 30, 1917.

*Receipts.*

| | | |
|---|---|---|
| Balance at previous report | | $ 480.95 |
| Five copies Proceedings | | 2.50 |
| Advertisements in 1916 Program | | 265.00 |
| Advertisements in 1917 Program | | 24.00 |
| Membership dues at $2.50 | $1,920.00 | |
| Membership dues, irregular | 119.15 | |
| Total membership dues | | 2,039.15 |
| Total receipts | | $2,811.60 |

*Expenditures.*

| | | |
|---|---|---|
| Subscriptions to School Science and Mathematics | | $1,107.25 |
| Subscriptions to American Journal of Home Economics | | 108.50 |
| Proceedings, 1916, printing and distributing | | 427.64 |
| Program, 1916, printing and distributing | | 275.02 |
| Rebates to local centers | | 4.00 |
| Miscellaneous: | | |
| Biology Section, expense | $ 8.00 | |
| Earth Science Section, expense | 7.32 | |
| Home Economics Section, expense | 2.10 | |
| Mathematics Section, expense | 15.00 | |
| Chemistry Section, expense | 4.81 | |
| Physics Section, expense | 3.85 | |
| Convention speakers | 70.30 | |
| President's expense | 21.57 | |
| Membership Committee, expense | 181.88 | |
| Secretary's expense | 10.77 | |
| Treasurer's expense | 62.50 | |
| Treasurer's salary 1915-16 | 25.00 | |
| Treasurer's bond | 2.50 | |
| Advertising Committee, expense | 10.50 | |
| Printing and stationery | 47.93 | |
| Excursion | 4.50 | 478.53 |
| Balance | | 410.66 |
| | | $2,811.60 |

*Membership Report for the Year Ending November 30, 1917.*

| | | |
|---|---|---|
| Paid-up membership, December 1, 1916 | | 973 |
| Honorary membership | | 9 |
| Total membership | | 982 |
| Delinquent, but left on the list as per Constitution | | 88 |
| Total names remaining on the list, November 30, 1917 | | 1,070 |
| New names added during the year | | 214 |
| Total | | 1,284 |
| Resigned during the year | 132 | |
| Deceased or dropped for delinquency | 65 | 197 |
| Net Constitutional membership, November 30, 1917 | | 1,087 |
| Paid-up membership, November 30, 1917 | | 990 |

JOHN H. MCCLELLAN,
*Treasurer.*

## Minutes of Biology Section, Central Association of Science and Mathematics Teachers.

On Friday, November 30, at 1:30 p. m., in Room 100 of the Biology Building of Ohio State University, the joint meeting of the Biology, Agriculture and General Science Sections was called to order by the chairman, Miss Nettie M. Cook, Springfield, Ill. In the absence of Mr. Jerome Isenbarger, Secretary of the Biology Section, the chairman appointed Miss Estelle Feldmann, Columbus, Ohio, as Secretary pro tem. The following three members were proposed to the chairman to serve on the Nominating Committee: Miss Francis Reinhard, Columbus, Ohio; Miss Nettie M. Cook, Springfield, Ill.; Miss Mary Goodard, Ypsilanti, Mich.

The chairman announced that the topics of the following program were those generally suggested as a result of the questionnaires that had been sent to all the members. Since these papers are given in the Proceedings, no abstracts of them are included in these minutes: L. J. Cole, University of Wisconsin, Madison, Wis., gave an illustrated lecture on "Plant and Animal Breeding in Relation to Biology Teaching in High School." E. N. Transeau, Ohio State University, Columbus, Ohio, read a paper on "The Rise of Sap in Trees." M. M. Wells, University of Chicago, Chicago, Ill., read a paper on "The Relation of Ecology to High School Biology."

The meeting adjourned until Saturday, December 1, at 10:00 a. m.

The Saturday morning meeting was called to order by the chairman.

Since the Executive Committee of the Agriculture and General Science Section was not present, Miss Spielmeyer of Cincinnati, Ohio, made a motion to have a joint meeting of the Biology, Agriculture and General Science Sections again. This was seconded by Miss L. Marzetti, Columbus, Ohio.

The Nominating Committee presented the following report: Chairman, Mr. Jerome Isenbarger, Nicholas Senn High School, Chicago, Ill.; Vice-Chairman, Miss Rousseau McClellan, Shortridge High School, Indianapolis, Ind.; Secretary, Mr. C. H. Sackett, Ben Blewett Junior High School, St. Louis, Mo.

The chairman turned the meeting over to G. R. La Rue, University of Michigan, Ann Arbor, Mich., leader of the Round Table. Mr. La Rue stated that he was interested in the problems confronting teachers and how they were solving them, as students were receiving part of their biological training in his department before entering on their teaching career. The program follows: "Note Books," C. H. Sackett, St. Louis, Mo. "School and Home Gardens with High School Botany," Miss Rousseau McClellan, Indianapolis, Ind. "Do College Courses as Now Administered Fit for Botany Teaching in High School?" Miss Mary A. Goodard, Ypsilanti, Mich. "The Present Status of General Science as to Content and Method," Mr. F. D. Barber, Normal, Ill.

Next was to have followed a paper by E. M. Gilbert, Madison, Wis., but since Mr. Gilbert did not agree with many statements made by Mr. Barber, he asked that the time allotted him for the reading of his paper be given to the discussion of these statements.

Discussion of the papers was next on the program.

Miss M. Flynn, Columbus, Ohio, objected to Mr. Sackett's statement, "by all means have the laboratory problem inked." She contended that a medium hard pencil served the same purpose and also saved time. Miss Cook, Springfield, Ill., thought it is not necessary to ink, as the laboratory problem was collected at the end of a period, put on file and de-

stroyed at the end of a semester. It was found necessary to do this in order to avoid copying. Miss Flynn thought the student should be allowed his laboratory problems at the end of the semester, as he very often used his laboratory book as a reference book. She had found this to be especially true of Normal girls. Mr. C. Recker, Columbus, Ohio, remarked that biology was not so stereotype a subject that different problems could not be used from year to year. Mr. La Rue, Ann Arbor, Mich., stated that very often the University required the laboratory book of a student, especially when they had no knowledge of the kind of science work being taught in the high school from which the student came.

Miss Speilmeyer, Cincinnati, Ohio, asked Miss McClellan if material was supplied to the children for their school gardens, or if the children raised their own early plants. Miss McClellan said that the teachers had friends and certain people who raised plants by thousands in frames and these were distributed to the children at a very cheap rate. Very little was given them. The chairman stated that this general enthusiasm for gardening throughout the country was not only for emergency but for the future. That the biologist of today does not know enough about practical gardening. This general movement towards home and school gardening was of great value to the child, as it gave him an opportunity to become acquainted with living things. That there are quite a few biological facts which a child of twelve years ought to know. He then told about a city boy taking a biological study at college making a statement that he had never seen a toad, and that it was the height of his ambition to go on a field trip and catch one. Such people, said the chairman, were very hard to handle in high school as well as college.

The chairman asked for some experiences of those who made field trips an integral part of their biology course.

Mr. Sackett, St. Louis, said that he usually conducts such trips on Saturdays. That they are purely voluntary. That the trips are carefully planned and that the pupils know just what to look for. Besides enriching their biological knowledge, it gives them a wealth of material which they use in their English.

Miss McClellan said that six to eight weeks were devoted to the study of insects and therefore she conducts three field trips in the fall. On these trips the pupils are taught to catch and collect insects. In the spring she takes up bird study. For this she finds evenings and early mornings, say 4 a. m., very good. As a result of these trips, pupils come to know 75 to 100 birds.

Miss Flynn, Columbus, Ohio, said that the science teachers of Columbus are permitted to take each class one afternoon a term on a field trip. That her classes always have their outlines ready and take notes in the field.

Since Mr. Gilbert had not agreed with Mr. Barber's statement that botany and zoology are losing out and within a few years will no longer appear on the course of study, the meeting was turned over to him.

Mr. Gilbert, Madison, Wis., said that as a matter of fact the colleges are up against it. English is the only study required. The pupil in selecting his course is not supposed to be advised. It is therefore in his Junior year that he sees the need of a biological study and then many inconveniences arise. Thus it is left entirely to outside forces to encourage the student in taking up a biological course.

Mr. Wells, Chicago, Ill., said that supposing the names of botany and zoology should be lost to the high schools, people nevertheless are not losing their interest in biological phenomenon but are studying botany and zoology under another system and name.

Mr. Gilbert said that botany has gained in Wisconsin. Schools that have never taught it before now teach it a half year.

Mr. La Rue remarked that the difficulty in Michigan has been that teachers have not been qualified to teach these subjects. Another reason is that colleges have not prepared the student to teach botany and zoology. It has offered an old stereotyped course, such as studying the hydra instead of some local animal, and does not solve at all any of the problems which a teacher would be apt to need in teaching biology. At present the University of Michigan is trying to make a course which will in time meet the demands of the biology teacher.

Mr. Wells, Chicago, Ill., said that he did not think that the lack of preparation and poor teaching on the part of the biology teacher forced the agriculture and domestic science teacher to teach biology because, as a fact, the poorest teaching was found among these.

Mr. Barber stated that he based his facts on those given him by the State School Commissioner of Wisconsin, and he ought to know.

Miss Cook, Springfield, Ill., said that general science increased the enrollment in zoology and botany in their schools.

Upon motion duly made and seconded, the meeting was declared adjourned by the chairman.

ESTELLE FELDMANN,
*Secretary pro tem.*

---

MINUTES OF THE CHEMISTRY SECTION, CENTRAL ASSOCIATION SCIENCE AND MATHEMATICS TEACHERS.

The Chemistry Section was called to order by Chairman Powers at 1:30 p. m.

In the absence of Secretary Ladd of Gary, Ind., Mr. A. C. D. Metzger of Columbus was chosen in his stead.

The chair appointed the following committees:

Nomination—Mr. Heilman, Mr. Weaver, Mr. Sharp.

Resolutions—Mr. McCarty, Mr. Abells, Mr. Collins.

Critics—Mr. Osborne, Mr. Smith, Mr. Williamson.

As there was no further business, the program as published was presented:

Prof. D. J. Demarest, Professor of Metallurgy, Ohio State University, read a splendid paper on "Special Applications of Chemistry in Shell-Steel Manufacture." After a few questions and a very brief discussion by Mr. Sharp, Chairman Powers, Mr. Gullum and others, the next paper was called:

"Laboratory Notes in High School Chemistry," by Mr. C. J. Pieper, University High School, University of Chicago. As Mr. Pieper was not present, his paper was read by Mr. Gullum of Columbus.

The discussion was led by Charles M. Sharp, Shortridge High School, Indianapolis. He said among many other things that he had not read the paper beforehand and would thus present some of his own views rather than a discussion of Mr. Pieper's paper. The objective points in High School Chemistry are: 1. Feeling for the work; 2. To think logically; 3. To view clearly the thing in hand; 4. To accomplish something; 5. To reason out a conclusion; 6. To state definitely a problem; 7. (and most important of all) to show observations and state the conclusions correctly. The student should be able to state the proper conclusion when tabulating his data. The problem in notebook work is to give the student some definite or specific thing to do, not give a general problem like making oxygen, etc.

Further discussion by Mr. Smith: Also by Mr. Stouffer and Mr. Osborne:

Mr. Jones of Cleveland told of his method of grading, using large sheet of bristol board for checking up the pupils, so that both he and the pupil would always know whether the work were kept up or behind.

He also stated that no pupil could get an A if his work was late or there was even a misspelled word in his book. Several members stated that Mr. Jones was too rigorous in his grading and that by so doing he would often lose the most essential thing in the notebook work—a feeling for the subject instead of English only.

Dr. McFarland at this point complimented the many good things that were stated in the paper and expressed his appreciation of what many high schools are doing in the concrete way of engendering a feeling for the work and a genuine scientific spirit in the chemistry pupils. He showed from his experience some of the following things: Examining and dealing with: (a) Theses for degrees; (b) Managers of industrial plants; (c) Chemical problems.

In (a): (1) They do not state definitely their problems; (2) Do not get accurate records of their experimental work; (3) Fail to pick up essentials and reject the nonessentials; (4) Not able to combine the data and get practical conclusions. All this is important in the commercial world as in the laboratory.

In (b), standpoint of managers: (1) Lack of ability to make an accurate report; (2) Do not keep proper records so that they can make a clear, concise report.

In (c), problem courses: (1) Not able to choose the proper literature bearing on the problem; (2) Fail to use proper design and methods of recording and explaining the work. Here the student must work out his own data. He has no data given; (3) Here, again, he often fails to make out a satisfactory, clear, logical report. This is *most important*, and nowhere can a student get the habit of doing this as well as in the high school, when he is in the formative period of adolescence.

After a few remarks by the Chairman, Miss Jessie Caplin, West High School, Minneapolis, Minn., presented "The Chemistry Show," which displayed among many other things the following:

1. A small Liebig's condenser.
2. Hot water heater.
3. Some books: Modern Science Reader, Book of Fiction $WO_2$, etc.
4. Pyrometer cones from pottery.
5. Pyro lighter.
6. Sulphur ore.
7. Sulphur cones in test tube.
8. Sulphur crystals, rhombic, etc.
9. Lead buckles.
10. Color photography.
11. Heavy iron screen.
12. Burning of Mg to show oxidation.
13. Paper-made burlap, ropes, etc.
14. Logarithms use in laboratory.
14$_1$. Jena glass, specimens, both good and bad.
15. Use of dental gold instead of gold leaf.
16. Coal tar model.
17. Asbestos.

18. China, good and bad.
19. Mohair, wool, cotton, etc.
20. Many pictures, etc.
21. Hydrogen generator, etc.

Miss Caplin's illustrations and experiments were well received and she was asked to have her show again next year.

Mr. Sharp showed:

1. Presolyte $CO_2$ cylinders.
2. Hoskin's alloys of alumel and cromel.

Mr. Jones spoke of his making liquid chlorine in field.
Meeting adjourned till next day.

*Chemistry Section, Saturday, 9:30 a. m.*

Chairman Powers called for reports of committees:

The Nomination Committee reported the following officers selected:

Chairman—F. B. Gullum, East High School, Columbus, Ohio.

Vice-Chairman—Raymond W. Osborne, Parker High School, Chicago, Ill.

Secretary—Miss Jessie Caplin, West High School, Minneapolis, Minn.

The above were declared elected.

Mr. Osborne showed some samples of conservation of fats made into soaps by his pupils.

At this time Mr. Heilman and Mr. Mahaffey explained the field trips, time for starting, etc.

As there were no members of the other committees ready to report, the program was taken up as per schedule:

Mr. Rivet read a paper on "The Place and Importance of Chemistry in the High School Course"—

Mr. Smith read a paper on "A Simple Method of Presenting the Atomic Theory."

In the absence of Dr. Bell, his paper was read by Mr. Powers. Subject, "A Study of the Attainments of High School Pupils in First Year Chemistry."

Dr. McFarland read a splendid paper on "The Work of the Amercian Industrial Chemist in War Time."

A brief discussion of Dr. McFarland's paper was participated in by Mr. Twiss in which he commended the paper and stated that teachers should show to their pupils (boys especially) the true and real value of chemistry, and give advice, i. e., vocational guidance, which is so much talked of nowadays.

Mr. Jones stated that they should be taught that the study of chemistry throws a strong light on industry. But not all are fitted to become chemists. Chemists are few. A boy must have chemical imagination plus a willingness to do good hard work.

After a few further remarks by Messrs. Smith, Abells, Dr. McFarland, et al., the remarks led to Dr. Bell's paper.

Mr. Jones spoke of the weakness of Dr. Bell's list of test questions. Mr. Osborne likewise criticized Dr. Bell's paper and suggested that it was not the sense of this body to accept his conclusions as anywhere near fina'.

As the hour was late, the meeting simply drifted apart without any formal adjournment.

Respectfully submitted,

A. C. D. METZGER,
*Secretary pro tem.*

---

MINUTES OF THE PHYSICS SECTION, CENTRAL ASSOCIATION SCIENCE AND MATHEMATICS TEACHERS.

Friday, November 31. The meeting was called to order by the temporary chairman, Mr. Charles T. Prose, of the Zanesville, Ohio, High School. Papers were presented by Mr. H. H. Reighley of the East Columbus High School, Prof. F. C. Caldwell of the Ohio State University, and Prof. J. A. Culler of Miami University. After a discussion of the papers, the following Nominating Committee was appointed by the chairman: Prof. F. D. Barber of Normal University, Normal, Ill.; R. H. Struble, Eastern High School, Detroit; Prof. George R. Twiss of the Ohio State University. Following adjournment the section visited the electrical engineering laboratories of the State University under the guidance of Prof. Caldwell.

Saturday, December 1. The meeting was called to order by the temporary chairman, Prof. J. A. Culler, of Miami University. Papers were given by R. O. Austin, formerly of the High School of Commerce, Columbus, Ohio, and by Franklin T. Jones, of the University School, Cleveland, Ohio. The remainder of the forenoon was given up to a discussion of these papers. The Nominating Committee presented the following names for the officers of the section for 1918:

Chairman—W. R. Aherns, Englewood High School, Chicago.

Vice-Chairman—Prof. F. R. Gorton, State Normal School, Ypsilanti, Mich.

Secretary—Clyde H. Krenerick, North Division High School, Milwaukee, Wis.

These were unanimously elected. During the afternoon the members of the section visited the city water works and filtration plant.

A. BJORKLAND,
*Secretary pro tem.*

---

## THE ALBERT TEACHERS' AGENCY.

The Albert Teachers' Agency of Chicago, which for the past fifteen years has been doing business at 623 S. Wabash Avenue, has moved its quarters to the New Kimball Building, 25 E. Jackson Boulevard. The constant increase in the business of the Agency has made this removal necessary. The Agency's new pamphlet, *Teaching As a Business*, contains interesting chapters on salaries as affected by the war, and much information of value to teachers and others engaged in educational work. Sent free to any address.

To bring its business nearer to many of its clients the Agency has established branch offices at 437 Fifth Avenue, New York City, under the management of S. A. MacKenzie; Spokane, Washington, C. R. Harmeson, Manager; and Denver, Colorado, John Girdler, Manager. These places have been chosen because they are large centers of population in which there are many good schools. The men at the head of these Agencies have had successful experience in the educational field and are believed to possess aptitude for Agency work.

## Educational Press Association of America

President, Henry G. Williams, Athens, Ohio.

Vice-President, H. R. Pattingale, Lansing, Mich.

Secretary, George L. Towne, Lincoln, Neb.

Treasurer, S. Y. Gillan, Milwaukee, Wis.

Executive Committee, O. T. Corson, Columbus, Ohio; H. T. Musselman, Dallas, Texas.

### Members

American Education, Albany, N. Y.
American Journal of Education, Milwaukee, Wis.
American Primary Teacher, Boston, Mass.
American School Board Journal, Milwaukee, Wis.
Atlantic Journal of Ed., Baltimore, Md.
Canadian Teacher, Toronto, Can.
Colorado School Journal, Denver, Col.
Educator-Journal, Indianapolis, Ind.
Florida School Exponent, Tallahassee, Fla.
Journal of Education, Boston, Mass.
Kansas Teacher, Topeka, Kan.
Kindergarten-Primary Magazine, Manistee, Mich.
Manual Training Magazine, Peoria, Ill.
Midland Schools, DesMoines, Iowa.
Missouri School Journal, Jefferson City, Mo.
Moderator-Topics, Lansing, Mich.
Nebraska Teacher, Lincoln, Neb.
New Mexico Journal of Ed., Santa Fe, N. M.
Ohio Educational Monthly, Columbus, Ohio.
Ohio Teacher, Columbus, Ohio.
Oklahoma School Herald, Oklahoma, City, Okla.
Pennsylvania School Journal, Lancaster, Pa.
Popular Educator, Boston, Mass.
Primary Education, Boston, Mass.
School and Home Education, Bloomington, Ill.
School Bulletin, Syracuse, N. Y.
School Century, Oak Park, Ill.
School Education, Minneapolis, Minn.
School News, Taylorville, Ill.
SCHOOL SCIENCE AND MATHEMATICS, CHICAGO, ILL.
Sierra Educational News, San Francisco, Cal.
Southern School Journal, Lexington, Ky.
Teachers' Monograph, Brooklyn, N. Y.
Texas School Journal, Dallas, Texas.
Western Teacher, Milwaukee, Wis.
Wisconsin Journal of Education, Madison, Wis.


## TRIANGLE WITH A BRAIN

That is what they call the "Arcascope," now in use in schools of every state and 23 foreign lands for it has these five points of merit:

**First,** it combines a triangle, protractor and three rules.
**Second,** it performs auxiliary steps such as multiplication, division, proportion, etc.
**Third,** it checks students' answers.
**Fourth,** it constructs symmetrical figures.
**Fifth,** it is a sort of assistant pedagogue.

The rules are the centimeter measure, eight inch rule divided into tenths and eight inch rule divided into sixteenths.

Flexible weight, **$4.50 per dozen;** double thickness, **$6.50 per dozen.**

**L. J. Leishman Company**

**Dept. U** **Ogden, Utah**


### THE OBEDIENT PLANT.

*Physostegia Virginica* is usually called false dragonhead or lion's-heart in the books, but the knowing ones call it obedient plant because of the curious habit the flowers have of keeping any position in which they may be placed. Turned either to the right or left, they do not spring back when released as other flowers do. The structure of the pedicel which makes such changes possible appears never to have been studied nor, so far as we know, has any attempt been made to discover what use this peculiar faculty is to the plant. Happening recently to pass numerous clumps of this plant on a windy day, we observed that all the flowers were turned away from the wind and remained in this position during lulls in the breeze. We are disposed to suggest, therefore, until a better explanation is forthcoming, that the yielding of the flower stalks to pressure of any kind serves to protect the essential organs by turning the opening of the flower away from danger.—[*American Botanist.*

## BOOKS RECEIVED.

Radio Communication. Theory and Methods. With an Appendix on Transmission over Wires, by John Mills, Western Electric Company. Pages xi+205. 12.5×18.5 cm. Cloth. 1917. $1.75 net. McGraw-Hill Book Company, New York City.

Religious Education and American Democracy, by Walter Scott Athearn, Boston University. Pages xi+394. 13.5×19 cm. Cloth. 1917. $1.50. Pilgrim Press, Boston.

Plane Geometry, by Claude I. Palmer, Armour Institute, Chicago, and Daniel P. Taylor, High School, Oak Park, Ill., edited by George W. Myers, School of Education, University of Chicago. Pages v+277. 13.5×20 cm. Cloth. 1915. $1.00. Scott Forsman & Company, Chicago.

The Botany of Crop Plants, by Wilfred W. Robbins, Colorado Agricultural College. Pages xix+681. 14×20 cm. Cloth. 1917. $2.00. P. Blakiston's Son & Co., Philadelphia.

College Algebra, by Ernest B. Skinner, University of Wisconsin. Pages vii+263. 13×19 cm. Cloth. 1917. $1.50. The Macmillan Company, New York City.

Education for the Needs of Life, by Irving E. Miller. Pages vii+353. 13×19 cm. Cloth. 1917. $1.25. The Macmillan Company, New York City.

The Natural History of Chautauqua, by Vaughan MacCaughey of the Chautauqua Summer School. 135 pages. 14×21 cm. Cloth. 1917. B. W. Huebsch, Publisher, New York City.

General Zoology, by A. S. Pearse, University of Wisconsin. Pages vii+366. 15×22 cm. Cloth. 1917. Henry Holt and Company, New York City.

Mathematics for Collegiate Students of Agriculture and General Science, by Alfred M. Kenyon and William V. Lovitt, Purdue University. Pages vii+357. 13×19 cm. Cloth. 1917. $2.00 The Macmillan Co., New York City.

An Elementary Study of Chemistry, by William McPherson and William E. Henderson, Ohio State University. Pages xii+576. 14×19 cm. Cloth. 1917. $1.60. Ginn and Company, Boston.

Science for Beginners, by Delos Fall, Albion College. Pages ix+382. Cloth. 1917. World Book Company, Yonkers-on-Hudson, New York.

Logarithms and Anti-logarithms, by C. H. Forsyth, University of Michigan. 46 pages. 15.5×23.5 cm. Cloth. 1917. 75 cents. George Wahr, Ann Arbor, Mich.

Exercise and Review Book in Biology, by J. G. Blaisdell, High School, Yonkers, New York. Pages viii+152. 20×26 cm. Paper. 1917. 80 cents. World Book Company, Yonkers-on-Hudson, New York.

## BOOK REVIEWS.

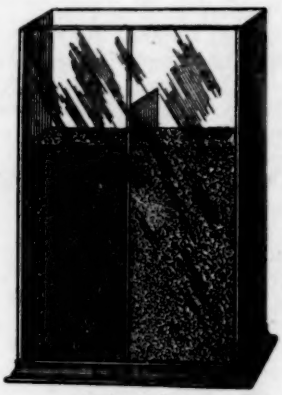
*A Textbook in the Principles of Science Teaching, by George R. Twiss, High School Inspector of the State of Ohio.* Pages xxvi+486. 14×20.5 cm. Cloth. 1917. $1.40. The Macmillan Company, New York City.

This splendid book is primarily for teachers who are in the service and as a textbook for the use of instructors who are giving courses to people in the theory of teaching. It is written by a person who is abundantly able to write upon matters of this kind, out of the rich fund that he has been collecting for many years in his high school work and in his contact with secondary school teachers. The book shows splendidly, in a practical and at the same time concrete way, how the recent developments in

## THE MATTOON WORM CAGE

**To Study the Work of Worms on Soils**

A metal cage of ample size, fitted with glass front and glass partition. Dry and wet soil, or humus and sand may be placed side by side. This Cage clearly illustrates the work of worms under controlled conditions.



30-245

**First Year Science Leaflet, No. 2,** with full instructions, supplied with the cage, or mailed on receipt of six cents.

**Apparatus for All Sciences.**
**Catalogs Free, On Request.**
**Quotations Prompt, Definite.**

**Supplies fully guaranteed.**
**Shipments—when you desire.**
**Prices always right.**

## Cambridge Botanical Supply Company

**LABORATORY EQUIPMENT—ALL SCIENCES**

**Submit Your Lists for Our Current Net Prices**

**1 to 9 Lexington Street** **Waverley, Mass.**

## THE AMERICAN MATHEMATICAL MONTHLY

**OFFICIAL JOURNAL OF**

## The Mathematical Association of America

**Is the Only Journal of Collegiate Grade in the Mathematical Field in This Country**

This means that its mathematical contributions can be read and understood by those who have not specialized in mathematics beyond the Calculus.

The Historical Papers, which are numerous and of high grade, are based upon original research.

The Questions and Discussions, which are timely and interesting, cover a wide variety of topics.

The Book Reviews embrace the entire field of collegiate and secondary mathematics.

The Curriculum Content in the collegiate field is carefully considered. Good papers in this line have appeared and are now in type awaiting their turn.

The Notes and News cover a wide range of interest and information, both in this country and in foreign countries.

The Problems and Solutions hold the attention and activity of a large number of persons who are lovers of mathematics for its own sake.

There are other journals suited to the Secondary field, and there are still others of technical scientific character in the University field; but the monthly is the only journal of Collegiate grade in America suited to the needs of the non-specialist in mathematics.

Send for circulars showing the articles published in the last two volumes.

Sample copies and all information may be obtained from the

**SECRETARY OF THE ASSOCIATION**

**55 East Lorain St.** **OBERLIN, OHIO**

experimental and educational psychology may be applied in science teaching. The volume will be exceptionally helpful to a large mass of science teachers of the older brand, at least, who have not seen fit to give the psychology of science teaching very much of a hearing in their professional work. If this class of teachers will carefully study the book they surely will find many suggestions which will enable them to teach more efficiently than they have been doing. Indeed, the text is a real handbook for any science teacher. It will help him over many difficult places. In schools of education this book may well be used where courses are given in the various sciences of which the book treats. In fact, it is a text that any person who is in any way connected with science teaching in secondary schools or schools of education cannot help but profit by studying.

There are twenty-four chapters under the heads of The Meaning of Science, The View Point for the Science Teacher, the Genesis of Science, Science and Children, Methods of Teaching, Educational Functions and Value of the Sciences, The Disciplinary and Cultural Values of Science, Classroom and Laboratory Instruction, Lectures, Examinations and Reviews, Equipment for Science Teaching, The Sciences and the Curriculum, Biology, Biological Equipment, Geography, Fundamental Principles of Geography, Methods in Geography, Geographical Equipment, Physics, Methods in Physics, Equipment for Physics Teaching, Chemistry—Principles and Methods, Chemistry—Practical Suggestions, Chemical Equipment, General Science Courses, and Examinations and Tests.

The diction is clear and the style simple. It is interesting reading for any science teacher. The book is printed in 10 point type on uncalendered paper. The major paragraphs have the key of the matter in each paragraph in a few words at the beginning in bold faced type. Each chapter closes with questions for further study, together with a bibliography of the matter treated in that chapter. There is a splendid appendix devoted to a list of science books for a high school library. A very complete index is appended.

It is a book that no science teacher should be without.

C. H. S.

*How to Make High Pressure Transformers, by F. E. Austin, Hanover, New Hampshire.* 46 pages. 11.5×18 cm. Paper. 1917. 65 cents. Published by the author.

*How to Make Low Pressure Transformers, by F. E. Austin, Hanover, New Hampshire.* 22 pages. 11.5×18 cm. 1916. 40 cents. Paper. Published by the author.

These are two of the most helpful little books on this subject which the writer has had the pleasure of reading and examining. Instructors in electrical engineering and constructive work in advanced physics cannot do better than to use these little books as texts and outlines for the construction of high and low pressure transformers. Any person who has a fair knowledge of transformers can use the books without assistance other than the illustrations contained in the texts. C. H. S.

*Stony Island—A Plea for Its Conservation, by Zonia Baber, School of Education, University of Chicago.* 16 pages. 15×23 cm. Paper. 1917. University of Chicago Press.

This little pamphlet is a wonderful and eloquent plea for the preservation of that tract of territory in the southeastern part of the city of Chicago between 91st and 94th Streets and extending from Stony Island Avenue eastward to Kingston Avenue. There are comparatively few people in the great city of Chicago who are aware of the existence of a

**Los Angeles** **Seattle** **St. Paul**
**Rochester, N. Y.** **Washington, D. C.**
and 3,000 schools in other places
use

# HAWKES-LUBY-TOUTON

## FIRST COURSE IN ALGEBRA, Revised Edition

The entire text has been rewritten and greatly simplified; new problems and exercises have been added; much simple oral drill is a feature. Altogether this book leaves little to be desired as a working text for first-year algebra classes.

## GINN and COMPANY

**Boston** **New York** **Chicago** **London**
**Atlanta** **Dallas** **Columbus** **San Francisco**

*Work for the Interest of*

**SCHOOL SCIENCE AND MATHEMATICS**

## UNMOUNTED LANTERN SLIDES
**IN PHYSICS AND CHEMISTRY**

During a long teaching experience some 700 negatives in Physics and Chemistry have been accumulated.

To enable schools to obtain slides at a reduced rate UNMOUNTED PRINTS on the best grade of lantern slide plates and accompanied by printed labels will be made from any of the negatives for 25 cts. each or $22.00 per hundred.

*Lists will be supplied on request.*

**C. M. Westcott, 1436 Alta Vista Blvd., Hollywood, Cal**

# Textbooks in Mathematics and Science for High Schools

WILLIAMS & KEMPTHORNE'S ALGEBRAS, by W. H. Williams, M. A. (Williams College), head of the Department of Mathematics, State Normal School, Platteville, Wisconsin, and W. B. Kempthorne, PH. M., instructor in Mathematics, University of Oregon, Eugene, Oregon.

THE WILLIAMS GEOMETRIES, by John H. Williams, head of the Department of Mathematics, Urbana, Ohio, High School, and Kenneth P. Williams, Ph. D., assistant Professor of Mathematics, Indiana University.

REED & HENDERSON PHYSICS, by John O. Reed, Ph. D., late professor of Physics, University of Michigan, and Wm. D. Henderson, Ph. D., Junior Professor of Physics, University of Michigan.

APPLIED CHEMISTRY, by Emery, Boynton, and Miller. "The contents are splendidly logical and teachable and unusually comprehensive."

Address

## LYONS and CARNAHAN

**CHICAGO**
**623 S. Wabash Avenue**

**NEW YORK**
**131 E. 23d Street**

rock outcrop such as is this Stony Island. For its educational value to the high school pupils of the city it should be preserved. In fact the city of Chicago ought to purchase this tract of land and hold it as a park where students and others may go and study the geological formation, as well as the unique vegetation there displayed. C. H. S.

*Examples in Magnetism, by F. E. Austin, Hanover, New Hampshire.* 90 pages. 12.5×19 cm. Paper. 1916. $1.10. Published by the author.

This little book tells one who has a knowledge of trigonometry and who is beginning the study of that subtle force, magnetism, of some of the things that he must master and do if he is to be successful in this phase of science work. The book will act as a splendid guide to those students who are beginning the study of electrical engineering. There are twenty-seven drawings and halftones given. The method of procedure is to give a particular example of the matter in question, with an explanation of it, after which the real problem bearing on the example is given. There are several tables appended which have direct use in the study of the book. The book is well worth the price, and every student in electrical engineering should possess a copy. C. H. S.

*Examples in Battery Engineering, by F. E. Austin, Hanover, N. H.* 90 pages. 12.5×9.5 cm. Cloth. 1917. $1.25. Published by the author.

A very complete and comprehensive discussion of the practical use of primary and storage cells, together with the theory and the mathematics of the same. Special stress is placed upon storage cells, which is a very valuable feature of the book. There are many things of an elementary nature in the book, and the more difficult part of it, under the Theory of the Storage Cell, can readily be mastered by anyone interested in cell work. As is customary with this author, he presents an example on a certain question which he wishes to discuss. This is followed by the solution and the discussion, after which a concrete example of a similar nature is presented. A bibliography is appended. The book should be in the hands of all students who are studying primary or storage cells. C. H. S.

*Radio Communication. Theory and Methods. With an Appendix on Transmission over Wires, by John Mills, Western Electric Company.* Pages xi+205. 12.5×18.5 cm. Cloth. 1917. $1.75 net. McGraw-Hill Book Company, New York City.

This book is really the gist of a course of lectures which were given by Mr. Mills in the summer of 1917 to a company of the United States Reserve Signal Corps troops. No one is better qualified to talk or write on this subject than the author of this text, and the matter presented in the book is authoritative in every respect. One without some training in radio work would be unable to handle the book alone, but when used as a textbook by a competent instructor it becomes clear and helpful to any student. The recent rapid development of radio activity and radio apparatus has been so marvelous that one is obliged to be on the alert continually if he is going to keep up to date with the progress of radiography. The present war has been an incentive to all people interested in this subject to improve on the apparatus and everything else of a mechanical nature used in the transmission of radiograms. Young men who are now enlisting in this phase of governmental work should possess copies of this book, and they no doubt will be brought in touch with competent Government instructors who will be able to lead them through the book, thus securing a knowledge of radiography which will stand them in good stead in the positions in which the Government will station them.

C. H. S.